NORA Years

Impacts:

NORA Research, 1996-2005

CDC Workplace Safety and Health

NIOSH

NORA

• Disclaimer •

The findings and conclusions in this report have not been formally disseminated by the Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health should not be construed to represent any agency determination or policy.

• Introduction •

In 1996 the National Institute for Occupational Safety and Health (NIOSH) and its partners unveiled the National Occupational Research agenda (NORA). NORA was developed by NIOSH and its partners in the public and private sectors to provide a framework to guide occupational safety and health research for the next decade. The effort to guide and coordinate research focused on 21 priority areas.

As a working blueprint for innovative research, NORA has stimulated strong support and broad partnerships across industry, labor, government and the academic community. Through NORA and its collaborative structure, the Nation is better positioned to counter the toll of workplace injury, illness, and death in this time of unprecedented change in the American workplace.

This document contains 446 abstract and impact statements from researchers who responded concerning their research projects identified as NORA from 1996-2005. The 188 extramural projects (out of 353 identified as NORA), 256 intramural projects, and two cooperative agreements illustrate the impressive range of NORA priorities and the high quality of research that continues to result from these national partnerships.

The intent of this document is to emphasize the importance of the transfer and translation of research findings, technologies, and information into highly effective strategies, practices and products that assist the prevention of injuries and illnesses of workers. A separate electronic collection titled A Compendium of NORA Research Projects and Impacts, 1996-2005 contains more complete project descriptions. The Team Document: Ten years of leadership advancing the National Occupational Research Agenda complements this volume and describes the accomplishments of the twenty NORA Teams. NIOSH is continuing to work with its partners to focus research on ways to develop effective products, translate research findings into practice, target dissemination efforts, and evaluate and demonstrate effectiveness.

What is clear from the NORA research effort is that it takes the collaboration of many parties, including labor, industry, academia, private organizations and government to maximize the return on research investment. By providing brief project summaries and contact information, we hope this impact document will provide a tool to improve networking among researchers, foster communication between researchers and end-users, and stimulate thinking on new research ideas and new ways to highlight impact. We all share the same goal: the protection, preservation and improvement of the health of people who work.

• Table of Contents •

1 Extramural Projects

• Allergic and Irritant Dermatitis •

Dermal Absorption of Cutting Fluid Mixtures

Project Period:
2000 - 2004

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Abstract:
Several of the cutting fluids/oils used in the metal-machining industry are known to cause skin irritation, yet very little is known about how additives in these formulations influence irritant diffusion and distribution in workers' skin. The primary objective of this project was to identify physicochemical and chemico-biological interactions that influence the dermal disposition of three cutting fluid additives that have been identified as causing occupational irritant dermatitis amongst workers. Physicochemical and in vitro skin diffusion studies were designed to identify these interactions. The biocide, triazine, was more likely than other performance additives to penetrate skin and was primarily responsible for the inflammatory response in skin. Cutting fluid additives and/or formulation contaminants influenced triazine disposition in skin. The data suggest that physicochemical interactions between the irritant biocide and the cutting fluid formulations played a significant role in modulating how much of these industrial irritants penetrate and distribute in skin.

Impact:
This project was the first to quantify the dermal absorption of cutting fluid additives. Assessing the dermal absorption of all known additives is impossible, therefore the focus of this project was to assess absorption of representative chemical classes of additives. The biocide appears to be more readily absorbed in skin than the surfactant or lubricant. However, the significant deposition of the latter two additives in skin tissue can lead to epidermal cytotoxicity. Soluble oil and synthetic fluids modulated additive absorption by different physicochemical mechanisms. Cutting fluid contaminants appear to influence additive absorption, and this raises further health concerns about used/aged cutting fluids. Finally, workers chronically exposed to cleansers/degreasers will likely absorb more cutting fluid additives across their skin. Further studies within the above physicochemical approach can be used to better predict the disposition of additives that are of an occupational health concern. This can lead to formulation of safer cutting fluids.

Non-invasive Evaluation of Contact Dermatitis In Vivo

Project Period:
2000 - 2003

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Co-Investigator(s):
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Abstract:
The differentiation of allergic contact dermatitis (ACD) and irritant contact dermatitis (ICD) poses a significant challenge to the dermatological practice. We used reflectance confocal microscopy (RCM) to describe the histopathological features of contact dermatitis non-invasively and in vivo. Subjects were patch-tested with allergens, irritants, and controls. RCM was used to non-invasively evaluate the skin sites for the presence of stratum corneum (SC) disruption, spongiosis, exocytosis, and vesicle formation.

Impact:
The findings described in our study reflect the need to improve the contact dermatitis diagnostic. Histological diagnosis and patch testing allow for only limited differentiation of ICD from ACD. The lack of diagnostic accuracy may result in inaccurate conclusions and inappropriate treatment. Our results suggest that allergic reactions may be differentiated from irritant reactions. The findings also show that there may be increased susceptibility to irritant contact dermatitis in Caucasian individuals compared to African-Americans. Furthermore, and most importantly, RCM facilitates the defini-

tion and recognition of even mild irritant reactions in the skin, thus prompting the development of new testing strategies in the cosmetic industry (which currently relies on unrealistic ex-vivo models, unrepresentative animal or invasive human models for pre-marketing testing of new cosmetic substances). Our findings would represent the basis for the development of a non-invasive, in vivo human model for cosmetic testing in a wide variety of settings.

Prediction of Irritation Based on Exposure Duration

Project Period:
1998 - 2002

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Co-Investigator(s):
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Abstract:
The broad, long-term objectives of this project were to develop a biologically-based mathematical modeling approach that could be used to derive duration-based standards for chemical irritancy. The specific objectives of this research were to understand the relationship between the duration of solvent exposure on the skin and the degree of irritation produced by chemicals representative of solvents and surfactants. We developed biologically-based models that can be used for distribution of chemicals in the skin. We measured temporal changes in some inflammatory proteins in the skin. We quantified oxidative species and low molecular weight DNA due to chemical exposure. We measured baseline gene expression and changes due to exposure to the three chemicals. Our conclusions were that this approach is an excellent model to study chemical irritation, and the responses of other proteins related to changes in mRNA that we found needed to be studied.

Impact:
These findings will be used to focus future studies on the molecular cascade in the skin that occurs with irritant chemical contact. Taken together, the findings in this study will refine our understanding of the irritant cascade and ultimately lead to a biologically-based mathematical model that can be used to predict chemical irritancy in the workplace.

Contact Dermatitis Prevention in Construction

Project Period:
1991 - 2001

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Abstract:
This project examined the causes, incidence, and controls for occupational contact dermatitis in the construction industry. Portland cement was identified early as the target of the research project. Multiple approaches were used to address the problem: surveillance, economic analysis, intervention effectiveness, communication, training material development, and information dissemination. The resultant communication materials offer the most comprehensive collection of reference materials for the construction industry on contact dermatitis problems and controls.

Impact:
The training program and educational material has been integrated into union-based apprenticeship and training curriculum. The publications developed under the research project are available and used by employers, associations, and unions nationwide. Most materials are disseminated through CPWR's elcosh.org Web site to the entire construction industry. Interventions identified have been moved into practice and have resulted in the reduction of disease based on anecdotal feedback from worker groups. Unique educational materials developed through the project have raised the construction industry's awareness of the severity and impact of occupational skin disease. The information generated during the research project significantly increased the quantity and quality of information on contact dermatitis in the construction industry, and CPWR anticipates that Federal agencies and the industry will use the information to improve working conditions for construction workers.

• Asthma and Chronic Obstructive Pulmonary Disease •

Lung Diseases in Chinese Textile Workers

Project Period:
1989 - 2006

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Abstract:
Exposure to gram-negative bacterial endotoxin has been described in laboratory studies as producing acute respiratory symptoms and lung function change. Most of previous studies focused on acute airway responses to endotoxin-contaminated cotton dust, and longitudinal data were scarce. To improve our understanding of the chronic respiratory effects from exposure to cotton dust and endotoxin, this study followed 447 cotton textile workers, and 472 silk workers (as controls) from 1981 to 2001. We observed both acute changes over work-shifts and longitudinal changes in lung function, respiratory symptoms, and measured workplace concentrations of cotton dust and endotoxin over the 20 years. This cohort study is unique since it includes comprehensive data and high follow-up rates over the long-term observation. In addition, the study followed both actively exposed workers and those who were removed from exposure by retirement over the 20 years, which allowed observing a natural history of cotton dust/endotoxin related airway disease.

Impact:
As a result of this study, recommendations were made based on the adverse health effects of exposure to cotton dust, leading to an adoption of dust control procedures in China for the cotton industry, resulting in decreasing concentrations of cotton dust in the workplace. In addition, the findings of this study have theoretical and practical implications in a variety of occupational settings where airborne endotoxin exposures have been documented, such as grain storage and processing, swine confinement buildings, poultry houses, sewage treatment plants, machining operations, biotechnology, and humidified buildings.

A Validated Asthma Questionnaire for Health Care Workers

Project Period:
2001 - 2005

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Abstract:
Recent reports show an increased occurrence of asthma among health care workers. Current literature focuses on predicting asthma in populations, and few studies have investigated a formal validation of asthma questionnaires. Phase I of the study developed and validated a new survey instrument of work-related asthma for use among health care workers. In Phase 2, the new survey instrument was administered to a population-based sample of four occupational groups of health care workers (RN, MD, RT, and OT). Out of 5600 questionnaires, 3650 were returned (response rate was 66%). In addition, an asthma risk-factor and healthcare worker-specific job-exposure matrix is being developed for application to the study. Currently analyses are being conducted to estimate and compare the prevalence of work-related asthma, analyze associations between occupational and nonoccupational exposures in health care workers with and without asthma in this population, and estimate the occupational burden of asthma in these groups.

Impact:
Healthcare workers represent approximately 7% of the U.S. workforce. Evidence exists suggesting that asthma prevalence

is higher in this group of workers than in the general population, and that potential exposure to asthmagens is high as well. Identification of specific exposures associated with the health services industry, through carefully designed projects like this one, is an important preliminary step in reduction and control of exposure to asthma risk factors.

Estimation of the Highest Task Silica Exposure

Project Period:
1998 - 2001

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Abstract:
More than one million workers are exposed annually to silica in the workplace. Despite efforts to decrease silica exposure in the workplace, overexposures and deaths from silicosis continue in certain operations and industries. The main objectives of this study were to investigate ways to estimate silica exposure in unsampled tasks and to evaluate the relationship between highest task silica exposure and the development of silicosis. Data from the North Carolina Dusty Trades, a unique resource for exposure-response studies of the effects of silica exposure, was the basis for the study. Three methods of imputation were used. The methods included estimating exposures based on the geometric mean exposure at sampled commodity-specific tasks, the median exposure of commodity-specific tasks, and a maximum likelihood estimation statistical model. A case-control study design was used to evaluate the effect that estimated silica exposure from the highest task had on the development of silicosis.

Impact:
While the three methods used to estimate missing data in the North Carolina Dusty Trades data are comparable and similar results were obtained when using no imputation, these methods could perhaps be used to estimate missing data in other investigations where task exposure is the exposure metric. Developing and testing the three methods not only permitted the evaluation of whether peak exposures increase the risk of developing silicosis, but also provided a foundation for future research studies that will advance our understanding of approaches for estimating missing exposure data. The findings from this study can serve as a guide to possible changes in sampling methods and targeted control techniques to reduce peak silica exposures that might be implemented to decrease disease in the workplace.

Isocyanate Exposure Intervention Study in Body Shops

Project Period:
2002 - 2000

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Abstract:
Painters and technicians in the auto body repair and refinishing industry are routinely exposed to aliphatic polyisocyanates through inhalation or direct dermal contact. Exposure to isocyanates may lead to sensitization or occupational asthma. Effective technologies and strategies to control exposures are greatly needed, but little has been done to evaluate any isocyanate exposure control methods. The main objective of this study is to implement an integrated exposure interventional program in selected auto body shops, and evaluate the effectiveness of various program components in reducing isocyanate exposures. Effective measures or products identified from this study can be recommended widely for applications in other body shops in this industry or similar industries to help reduce the risk of exposure to isocyanates and contribute to the prevention of isocyanate-induced health outcomes, particularly, isocyanate asthma.

Impact:
We have encouraged all participating shops and workers to use safer work practices, personal protective equipment, and effective skin cleaners. These methods significantly reduce workers' exposure to isocyanates and organic solvents, and improve their work practices, as reflected in the above results. Shop managers have gained information, awareness and attentiveness, and are becoming more OSHA/EPA compliant. Worker awareness is demonstrated in many small ways, such as avoiding the touching of uncured car surfaces and increasing the frequency of changing gun cleaning solvents. A significant impact may have come after we disseminated some of our results and recommendations to a National Autobody Congress & Exposition meeting and press conference. As a result, local distributors have moved towards providing more protective nitrile or double latex gloves to auto body shops. Our findings are being translated into safer actions beyond the shops we have worked with.

Initial Respiratory Responses in Welding Apprentices

Project Period:
2000 - 2004

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Abstract:
Promising findings from Fishwick et al. (Scand J Work Environ Health, 1997) have documented an acute respiratory response to welding 15 minutes after first daily exposure. To further pursue this finding along with evidence of increased airway reactivity in welders, we conducted a study of "naïve" welding apprentices with baseline and 6-month follow-up airway reactivity tests and measured real-time welding exposures along with serial pulmonary function tests (PFTs). Approximately 200 apprentices participated. No changes in airway reactivity were found for welders. Average levels of welding fume exposures (3.0 mg/m3) were below regulatory standards but higher peak exposures were measured. Changes in lung function across a welding session were associated with number of peak exposures and cumulative exposure under peaks, suggesting that peak exposures have potential physiological effects.

Impact:
As this study was designed, its impact can be measured by increased knowledge of acute respiratory responses to early welding experience and by improved characterization of welding exposures. Additionally we provided suggestions for optimal ventilation system designs to the training centers. Participants received their lung function test results and an increased awareness of welding exposure hazards. Workers generally accepted that welding is not good for the lungs. The research literature seems mature enough to focus on interventions to reduce welding exposures. We considered providing respirators for participants but we did not because of the liability issues surrounding OSHA's requirement for an employer-implemented Respiratory Protection Program for voluntary use of respirators. From previous intervention research in our Construction Occupational Health Program, we have noted that achieving farther-reaching impacts requires a study designed for intervention that involves the participants in the planning and implementation.

Iron, Calcium and Oxidative Stress in Lung Injury

Project Period:
1999 - 2003

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Abstract:
Striking differences in the prevalence of coal worker's pneumoconiosis (CWP) exist among different coal mine regions

despite comparable levels of dust exposure. The goal of this project was to assess (1) whether bioavailable iron (BAI) is the potentially active component in coal dust-induced cell injury and (2) whether the differences in levels of BAI may be responsible for the observed regional differences in CWP prevalence. To reach this goal, cell-free systems mimicking phygolysosomes as well as tissue cultures of various types of lung cells were used. A large number of coal samples from three coalmine regions of Pennsylvania, West Virginia, and Utah were tested in these systems. Levels of BAI, iron proteins, oxidants, and cytokines were measured. Based on the results of the BAI measured in the laboratory as well as published data from The National Study of CWP and US Geological Survey, a model was developed for the prediction of coal's toxicity.

Impact:
Based on the linear fit of CWP prevalence and the BAI levels in the coals, pneumoconiotic potencies of seven thousand coal samples were derived and mapped. Levels of BAI in coal may be used for the prediction of coal toxicity, even before large-scale mining. Because of the findings on BAI by this project, changes in iron status as well as cytokine levels in serum may be used as exposure and disease markers in coal workers. The same findings can also be applied in workers of iron ores and steel factories.

Passive Sampler for Particles

Project Period:
1998 - 2000

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Co-Investigator(s):
n/a

Abstract:
This pilot study evaluated the operation of a prototype passive aerosol sampler about the size of a dime that costs only a few dollars. The sampler collects particles by gravity, diffusion, and convection. It was tested in a wind tunnel under controlled conditions. Limited field trials were conducted at an industrial site where the performance of passive and conventional samplers could be compared.

Impact:
This work has led to the development of a miniature, passive aerosol sampler that will reliably estimate both the long-term average concentrations and size distributions. This sampler is about the size of a dime, costs only a few dollars, and collects particles by gravity, diffusion, and convection. These passive aerosol samples are examined with scanning electron microscopy (SEM) and analyzed using a refined deposition velocity model and the measured particle flux to the sampler to obtain estimates of average concentrations and size distributions. The accuracy and precision of the passive sampler are not dependent on relative humidity, wind speed, or aerosol concentration. Field tests in an occupational environment confirmed that the size distribution and concentration data for the passive sampler correlated well with those from a conventional sampler. A patent application for the passive aerosol sampler has been filed through the University of North Carolina at Chapel Hill.

Preventing Occupational Latex Allergy in Health Care Workers

Project Period:
1996 - 2003

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Abstract:
Studies have implicated exposure to natural latex gloves in development of latex sensitization (LS) among healthcare workers (HCW). HCW from two hospitals (A & B) were studied prospectively, to determine the incidence of latex sensitization before and after glove interventions consisting of removal of powdered latex gloves, and replacing all gloves with either powder-free latex or synthetic gloves. Between 8/98 and 8/02, participating HCWs (A - 305, B -500) completed 2775 serial skin tests (A –972, B-1803). Initial prevalences of LS were A – 18/305 (5.9%) and B - 21/500 (4.2%). Prior to the glove interventions, HCWs from both hospitals developed

LS (A - 2/257, B - 5/448), but after the glove interventions no HCW developed LS during 32 months of observation. Before the interventions, no HCWs reverted from skin test positive to negative; afterward four reverted. Development of LS is associated with use of powdered latex gloves in hospitals and can be eliminated by exclusive use of powder-free latex or synthetic gloves.

Impact:
The NIOSH publication was widely distributed, and the recommendations were widely adopted. According to industry figures, there has been a surge in demand for powder-free examination gloves, and by the first quarter of 2001, powder-free examination glove sales accounted for 80 percent of the total unit sales of examination gloves to U.S. hospitals. The reduction in use of powdered latex gloves has been associated with a reduced risk for developing latex allergies. Several recent studies have documented a decline in reports of latex allergy among health care workers in relation to the adoption of recommended control measures, which translates into reductions in workers with symptoms and disability.

Peak Exposures in Aluminum Smelting

Project Period:
2000 - 2004

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Abstract:
Workers operating aluminum smelting "potrooms" are at increased risk of asthma and other respiratory conditions although the etiologic agent(s) remain unknown. Peak exposures to HF and SO2 were assessed in four aluminum smelters with direct-reading instrumentation (DRI) developed for this study. Particulate matter exposures were assessed using existing instrumentation. The exposures were characterized within specific job tasks and were modeled as a function of smelter technology, location, work task, etc. Calibration of the DRIs occurred with Time-integrating filter samples for HF/SO2 as well as particulate matter. Work observations were conducted in order to identify the tasks conducted and determine the location of the worker during the monitoring. Sets of exposure/dose metrics were developed to characterize exposure and pulmonary dose. These metrics account for the variable exposure distributions and the time-course of exposure. Alternative metrics using average exposures and the metrics incorporating peak information and pulmonary dose estimates were compared.

Impact:
The exposure data have been used by a respirator manufacturer in the design of a respirator cartridge for hydrogen fluoride. They incorporated the average and peak exposure data into adsorption equations to extrapolate the service life of the new cartridges. Peak exposures to HF are available for the first time and allow the employer to compare these peak exposures to existing exposure limits including the NIOSH REL – C of 6 ppm and the American Conference of Governmental Industrial Hygienists (ACGIH) TLV-C of 3 ppm, both involving peak exposures.

Chronic Obstructive Pulmonary Disease Risks in Carpenters

Project Period:
2002 - 2004

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Abstract:
High particulate exposures can cause respiratory tract irritation and can overload the clearance mechanisms of the lung, which in turn can produce a cascade of responses that may culminate in chronic lung injury. To contribute to the study of risk associated with exposure to a mixture of particulates, the investigators targeted a working population of union carpenters. Carpenters have a diversity of aerosol (wood dust being only one) and chemical exposures and excess risk for pulmonary disease. We developed methods to (1) identify incident cases of Chronic Obstructive Pulmonary Disease (COPD) in the Carpenters Combined Benefits Fund of Massachusetts medical insurance records database and (2) develop a job-specific matrix that characterizes a diverse range of aerosol

and gas exposures associated with carpenter jobs and job task. In addition, we determined the feasibility of carrying out a case-control study by matching COPD incident cases to members of the fund eligible for insurance coverage at the time of diagnosis of the case.

Impact:
This study determined that it is feasible to undertake a case-control study of COPD among union carpenters. The Fund was able to provide access to their medical insurance database for this pilot study using electronic records dating from the early 1990s. The results of the pilot study found that (1) the database proposed for the study has enough cases to provide adequate power for such a study (2) electronic records include ICD codes for all and CPT codes for many, and (3) the database organization permits matching to identify eligible controls. In addition, we determined that (1) carpenters have a range of exposure levels to a mixture of particulate and chemical agents, (2) carpenters engage in a range of tasks and operations with different types and levels of exposure, and (3) it is feasible to collect task- or operation-specific work history data on active and retired carpenters.

• Cancer Research Methods •

P53 Biomarker and Intervention in Occupational Cancer

Project Period:
2002 - 2005

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Abstract:
Research methods for occupational cancer are needed to develop early markers of adverse health effects from workplace exposure and to devise ways for interrupting the pathways between workplace exposures and resulting cancers. Occupational exposures can produce mutations in the p53 tumor suppressor gene with the generation of p53 autoantibody biomarkers. We have demonstrated that certain short peptide sequences from p53 can cause mutant p53 to revert to normal function, resulting in the death of cancer cells containing mutant p53. The purpose of this research was to examine both of these approaches for cancers caused by asbestos exposure. First, banked serum samples from a cohort of workers with asbestosis were examined for p53 autoantibodies to determine whether their presence correlated with subsequent development of cancer. Second, we investigated the effects in cell culture of a p53 peptide on asbestos-associated cancers with and without p53 mutations and corresponding non-cancer cell lines.

Impact:
If these results are substantiated in other studies, p53 autoantibodies could be used to identify asbestos-exposed workers at high risk for the development of cancer who could be targeted for more aggressive preventive interventions. The p53 peptide could serve as the treatment (or prevention) of asbestos-associated cancers or other cancers containing p53 mutations. A patent has been applied for based on this approach and further animal testing is being pursued in preparation for human studies.

Time-Factors in Exposure Effects among Uranium Workers

Project Period:
2002 - 2004

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Abstract:
We evaluated the influence of temporal patterns of exposure to ionizing radiation on lung cancer mortality among workers at the US Department of Energy (US DOE) Y-12 uranium enrichment facility at Oak Ridge, TN. The analyses made use of vital status and cause of death information and incorporated updated radiation dose estimates. We applied analytical methods to evaluate the effects of latency, time-since-exposure, and age-at-exposure. There was minimal evidence of association with doses accrued in the periods 15-24 and 25+ years after exposure, when a time-dependent bilinear exposure weighting function was used. Radiation effects on lung cancer reached their peak 4 years after exposure and diminished thereafter. Under the sigmoid function, radiation effects

on lung cancer increase with increasing age at exposure, with an inflection point for the sigmoid curve at 37 years of age.

Impact:
These findings add to the occupational literature on risks of chronic exposure to low-level ionizing radiation. Methods for analyzing age at exposure and for modeling selection effects will be useful for future studies. Further analyses of variation in radiation risks with time-since-exposure and age-at-exposure may be useful for informing implementation of the Energy Employees Occupational Illness Compensation Program Act.

Prospective study of mesothelioma mortality in three zeolite-exposed villages in Cappadocia, Turkey

Project Period:
2003-2005

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n/a

Abstract:
Mesothelioma incidence is increased in certain villages on the Anatolian plateau in Turkey, the causation being environmental exposure to zeolite fibers from volcanic tuff. A prospective study of residents of two exposed and one unexposed village was initiated from 1979 until the end of 2003. 891 men and women, 20 years of age or older, total, were included, 230 of them residing in a village without exposure to zeolite. When standardized to the world population, total mesothelioma incidence was approximately 600 and 150 cases per 100,000 annually in the two exposed villages, and less than 10 in the control village. Standardized mortality rates using Danish mortality data for comparison were 287 for men and 1442 for women. These data support and extend current information on the mesothelioma endemic in zeolite-exposed areas of Turkey. They also suggest that this endemic will remain for decades, and that prevention will present a challenge.

Impact:
These data support and extend current information on the mesothelioma endemic in the zeolite-exposed areas of Turkey. They also suggest that this endemic will remain for decades to come, and that prevention will present a substantial challenge.

Cancer Incidence in Fluoride-Exposed Workers

Project Period:
1982 - 2004

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n/a

Co-Investigator(s):
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Abstract:
Workers at the Copenhagen cryolite plant were exposed to high levels of fluoride-containing dust before 1962. A follow-up of cancer incidence has now been extended by 12 years until the end of 1999, at which time most workers had died. Expected numbers of cancer cases were calculated by using the cancer-site–specific incidence rates for Copenhagen men. The average length of follow-up was 32 years. Forty-three new cancer cases occurred, including 12 cases of primary lung cancer and three bladder tumors. Most new cancer cases occurred in workers who were younger than 35 years when first employed and after a potential latency of more than 30 years. These new cases augmented the tendency of increased risk particularly in the subgroup with at least 10 years of employment, after an extended lag time and in workers who were young at the beginning of follow-up. The distribution of the 20 bladder tumors by grade was similar to those in the general population. These findings support the notion that occupational fluoride exposure may be a risk factor for bladder cancer.

Impact:
The plausibility of a cancer risk in fluoride-exposed workers must be judged in relation to the wide range of biochemical effects caused by low concentrations of this toxicant even though the experimental evidence for genotoxicity and carcinogenicity is equivocal. Following inhalation of cryolite dust, fluoride concentrations in urine may be very high, and fluoride retained in the skeleton may lead to elevated concentrations of fluoride in urine many years after exposure has ended. We therefore believe that fluoride should be considered a possible cause of bladder cancer and a contributory cause of primary lung cancer.

• Control Technology and Personal Protective Equipment •

Roll-Over Protective Structure (ROPS) Design and Testing for Agricultural Tractors

Project Period:
1998 - 2002

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Co-Investigator(s):
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Abstract:
A roll-over protective structure (ROPS), as described in American Society of Agricultural Engineers (ASAE) S519, is a protective structure designed to minimize the frequency and severity of operator injury resulting from accidental tractor upset. ROPS utilization has been shown to dramatically reduce fatalities during tractor overturns. But some agricultural tractors do not have appropriate ROPS designs and ROPS are not available. This project investigates and evaluates roll-over protective structure (ROPS) designs for agricultural tractors in the United States to provide operator protection on tractors and in operating conditions not currently available.

Impact:
Our analysis indicated that of the 70 most popular tractor models in the United States, 50.4% were pre-ROPS tractors. Of these tractors, 73% are included in this (and a previous) ROPS design study. With the completion of this ROPS design research project, 89.6% of the pre-ROPS tractors (in the top 70) will have a ROPS design. ROPS can be successfully designed for the John Deere A and Allis Chalmers pre-ROPS tractors. These ROPS meet ASAE S519 (SAE J2194) standards. Conducted axle housing tests demonstrated the ability of the axle housings to attain the stresses produced during the static longitudinal tests without failure. The ROPS are able to withstand the forces produced during the field upset tests. This study revealed the ROPS designs that can successfully be used to mount ROPS to pre-ROPS tractors. Tractor ROPS manufacturers can understand the opportunities and problems associated with mounting ROPS on pre-ROPS tractors.

Field Studies with Innovative Safe Excavation Technology

Project Period:
2001 - 2005

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Co-Investigator(s):
n/a

Abstract:
This research project focused on two specific work-related hazards of pipe installation, cave-ins, and underground utilities. Both thrusts addressed the problems through technological interventions. The fundamental approach to eliminating the deadly consequences of cave-ins was to remove the need for people to enter the trench. To test the feasibility of telerobotic alternatives to today's hands-on method, two types of pipe manipulators were designed and successfully tested. One is able to handle large concrete pipes while the other installs long pipes with gasket joint seals. The Buried-Utility-Detection-System (BUDS) uses a multi-sensory approach to underground sensing. An Equipment-Mounted BUDS system was fabricated and programmed to search for buried pipes and pinpoint the location with the antenna as a pointer. By using a wavelet-based approach to filtering raw GPR data, drastic advancements in accurately exposing the location of buried pipes were made. Most importantly, the filter worked also for non-metallic materials.

Impact:
This project proved the functionality and economic value of two sets of technological interventions designed to: (1) eliminate deaths through cave-ins and (2) drastically reduce accidents caused by damaging buried utilities during excavation. The developed and tested technologies are ready to be transferred into the industry. What is necessary are manufacturers willing to build and market the prototyped devices.

System for Measuring Workplace Protection Factors

Project Period:
1999 - 2003

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Co-Investigator(s):
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Abstract:
Existing methods for measuring workplace protection factors (WPFs) entail continuous sampling of ambient and in-mask environments using two sampling pumps. This project focused on developing an intermittent sampling system to measure contaminant concentrations inside respirators during inspiration, while sampling the ambient environment during exhalation. This addresses potential problems associated with continuous sampling including biased results due to lower contaminant concentrations in exhaled air and sample humidity. The system is based on a pressure transducer-activated solenoid valve that enables a single pump to alternately sample in-mask and ambient environments. Charcoal tubes are used to trap contaminants, making the approach widely applicable. A pressure transducer, sampling pump, solenoid valve, and data-logger were integrated into a single battery-powered unit measuring 8"x4"x2.5" and weighing < 2.5 lb. Interface circuitry allows continuous monitoring of heart-rate and in-mask pressures so that estimates of work and ventilation rates can be recorded with the WPF.

Impact:
This research has led to the development of an instrument for use in gathering WPF data for gases and vapors. The sampling system is small and light-weight, allowing it to be worn easily on a worker's belt, and has adequate battery power to operate for a full 8-hour shift. This technology should help address research needs identified in the Final Rule of OSHA's Respiratory Protection Standard. Data gathered using the instrument could be used in developing and evaluating APFs for different types of respirators, or as an exposure assessment tool for specific applications of respiratory protective equipment. The use of calibrated pressure transducers to measure respiratory flow rates and cumulative filtered air volumes could find use as an aid to estimating service lives and for indicating scheduled cartridge replacements. The system could easily be modified for breath sampling to characterize the pharmacokinetics for volatile organic compounds.

Integrated Stability Mapping System for Mines

Project Period:
2002 - 2004

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Co-Investigator(s):
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Abstract:
This project encompasses the development of a software tool that is designed to allow the mining engineer to effectively combine the geologic characteristics, structural features and stress influences at a mine site into an integrated stability mapping system for use in support design and mine planning. This stability mapping system utilizes the popular AutoCAD and/or SurvCADD platform as a foundation for inputting the geologic characteristics, and then integrates the boundary element program LaModel for determining the stress influences. The stability program allows the user to apply various weighting functions to the input geology and stress factors and then generates an overall stability index map for the mine property.

Impact:
This project is not yet completed and is still in the development and trial stage. However, upon completion, it is anticipated that through application of the integrated stability mapping system, mine engineers can obtain foreknowledge and a better understanding of unstable mining areas. With this enhanced knowledge, the mine and support design can then be optimized in order to develop safer and more productive mines.

Respiratory Protection Against Bioaerosols in Agriculture

Project Period:
2001 - 2005

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Abstract:
Agricultural workers are exposed to high concentrations of airborne microorganisms and thus have an increased risk for developing respiratory diseases. Respirators, when properly selected and used, can decrease the exposures in agricultural environments. The OSHA respiratory protection standard does not apply to agricultural workplaces and there are no general guidelines for respiratory protection against bioaerosols. This is mainly due to the lack of field-based data on the performance of respirators against biological particles. In this study, a new field-compatible method was developed to dynamically measure the protection provided by respirators against dust in agricultural environments. This method includes filter sampling to determine the protection provided by respirators against biological particles (fungal and actinomycete spores, bacteria).

Impact:
The results of this study provide useful pilot data to establish guidelines for respiratory protection against airborne dust and microorganisms in agricultural workplaces. The method is a promising tool for further epidemiological and intervention studies in agricultural and other occupational and non-occupational environments contaminated with airborne dust and bioaerosols. The results were the basis of a brief submitted to OSHA for consideration in the revision of the proposed rule for assigned protection factors of respirators.

Control Measures for Silica Exposures for Tuckpointing

Project Period:
2002 - 2005

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University of Iowa

Abstract:
This project encompasses the development of a software tool that is designed to allow the mining engineer to effectively combine the geologic characteristics, structural features and stress influences at a mine site into an integrated stability mapping system for use in support design and mine planning. This stability mapping system utilizes the popular AutoCAD and/or SurvCADD platform as a foundation for inputting the geologic characteristics, and then integrates the boundary element program LaModel for determining the stress influences. The stability program allows the user to apply various weighting functions to the input geology and stress factors and then generates an overall stability index map for the mine property.

Impact:
Although the ventilated grinders do not fully and adequately control the silica exposures, worker exposures are sufficiently reduced so that half-face piece air purifying respirators may be appropriate in many situations. Without the use of the ventilated grinders, workers would need to wear respirators that have an assigned protection factor of more than 100. Air line respirators do not appear to be practical control measures on scaffolds and swing stages. The exposures during mortar removal are so large and the need for control recommendations is so urgent that draft control recommendations were prepared at the request of the Center to Protect Workers Rights (CPWR) and these recommendations are available on the CPWR Web site. This document recommends a holistic approach including ventilated grinders, respirators, and a comprehensive management program. The Bricklayers and Allied Crafts Union has distributed these recommendations.

Improved Health and Safety in Mining through Helical Drilling and Rock Bolt Anchoring

Project Period:
2002 - 2006

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BHP Billiton (San Juan Mine)

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Abstract:
Roof falls in coal mines continue to be one of the greatest safety hazards faced by underground coal miners. Rock bolts, used in underground mines to stabilize rock masses, only ensure structural integrity when anchorage is maintained. Grout, used to bond roof bolts into drilled holes, currently cures in smooth boreholes created by drilling technology and rock bolt installation methods now used by the coal mining industry. The proposed research effort has entailed development of an innovative rock bolt, hole-drilling system, which allows the grout to cure more securely in ridges created by a new Helical Drill Bit technology. This system has been found to dramatically enhance anchorage dependability, particularly in weak rock, where anchorage is of greatest concern. The ability to improve rock bolt anchorage in the underground mining environment significantly improves coal miner safety and health by providing a more trustworthy and efficient solution to existing anchorage methods.

Impact:
The vast majority of coal mining occurs in underground mines where safety is of paramount concern. Roof falls are shown to be a significant threat, causing numerous deaths and nearly 3,000 injuries between 1995 and 1998. The ability to improve rock bolt anchorage in the underground mining environment, particularly in weaker rock, affects the structural integrity of the underground mine roof, and, therefore, miner health and safety. Helical Drill Bit technology and the improved Helical Rock Bolt work together to significantly reduce the risk of catastrophic roof failure. This improvement efficiently provides a solution for increasing anchorage, and may allow fewer and/or shorter roof bolts to be used to accomplish this objective.

This efficiency is significant when one considers the 68 million grouted rock bolts that the underground mining community currently uses each year.

Measurements and Control Diesel Emissions in Underground Mines

Project Period:
2002 - 2005

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Abstract:
The diesel particulate matter (DPM) emissions in underground mines are much higher than other occupational exposures and pose high health threats to mine workers. This project is aimed at developing a novel control technology to substantially reduce DPM and other gaseous diesel exhaust emissions and to evaluate the impact of this control method by performing a thorough characterization of DPM emissions in target underground mines. DPM emission measurements (such as area-of-interest sampling, personal exposure, and emission source sampling) will be performed, and the technology will be implemented in a selected mine or mines for demonstration purposes.

Impact:
The ESP technology will be very promising in DPM control and will offer a highly competitive (if not better) alternative to the existing diesel particulate filters. The research results in better understanding of the emission characteristics of non-road diesel engines, especially diesel generators, while most of the existing research focused on on-road diesel vehicles. DPM concentrations, the organic and elemental carbon (OC and EC) distributions and the individual compositions have been studied under various engine loads and various fuel sulfur contents.

In addition to peer reviewed journal publications and conference presentations/proceedings /preventions, it will result in two PhD dissertations and two MS theses.

Improving the Work Environment in Livestock Buildings

Project Period:
1999 - 2002

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n/a

Co-Investigator(s):
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Kansas State University

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Abstract:
This research evaluated the potential of incorporating local supply ventilation systems in a pilot-scale experimented facility, which simulated a swine building equipped with commercial ceiling diffusers. We evaluated relative ventilation effectiveness and spatial variability in dust concentration in a pilot-scale experimental facility. Results suggest that the local supply ventilation systems, in which supplemental air was introduced directly at the service alley, improved the ventilation effectiveness at the alley compared to commercial box-type diffusers. In addition, this research showed the potential of local supply ventilation in ensuring adequate air quality at or near the workers' breathing zone and also at the animal-occupied zone. Additional research is needed to establish guidelines and parameters for successful implementation and operation of the local supply system in livestock confinement buildings. In addition, field-scale demonstration of the system is warranted.

Impact:
This research illustrates the potential of local supply ventilation in ensuring adequate air quality at or near the workers' breathing zone in livestock confinement buildings. In particular, a system in which fresh or clean air is introduced down the alley to the workers' breathing zone in combination with a conventional ceiling diffuser performed the best in terms of relative ventilation effectiveness at the alley, overall relative ventilation effectiveness for the room, and spatial variability in dust concentrations. Such a local supply or zonal ventilation system could be used for farrowing and nursery rooms for swine. However, additional research is necessary to establish guidelines and parameters for successful implementation and operation of the local supply or zonal ventilation system in livestock confinement buildings. Such research should involve a combination of experimental and numerical simulation research. In addition, a field-scale demonstration of the system is warranted.

SBIR Bioelectronic Telemetry System for Fire Fighter Safety

Project Period:
2004 - 2006

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Testing and Analysis

Army Research Laboratory
Technology Transfer

Co-Investigator(s):
n/a

Abstract:
Extreme Endeavors is currently designing a state-of-the-art, innovative and non-cumbersome device that will monitor and transmit data concerning the physiological and environmental conditions that firefighters face while working inside structural fires etc. The initial beta version transmitted data containing information such as heartbeat, respirations, and voice sounds. In Phase II of this project Extreme Endeavors is engaged in implementation of a Least Squares Harmonic Analysis (LSHA) in real-time on board a state-of-the-art Digital Signal Processing chip. This will allow us to embed the device within the firefighter's turnout gear and provide the transmission of reliable physiological information with a limited amount of bandwidth. This telemetry system will maintain dual frequency capabilities and utilize a nodal/repeater system, allowing one firefighter to relay another firefighter's signal out of the structure, thus allowing firefighters to maintain voice communications regardless of their location within a building.

Impact:
Extreme Endeavors and consulting has moved into Phase II of the Electronic Life Line project. Our goal is to develop a reliable, robust, usable device that will revolutionize safety for working firefighters. During the disaster on 11 September 2001, complications in communications amongst firefighters responding inside the World Trade Center towers was directly responsible for many of the deaths that occurred. The Electronic Life Line (ELL) system will not only allow commanders to monitor the vital signs of firefighters in their units, but the device will also enhance the communication ability between firefighters, allowing them to communicate with one another via radio no matter what their location is within a structure. The ELL system is being designed to impact the way the fire fighting industry addresses and responds to the growing need to improve organizational protocols within fire fighting

companies, to improve the health and survival rate of firefighters, and to improve general communications systems.

Ergonomic Solutions For Furniture Manufacturers

Project Period:
1999 - 2003

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Co-Investigator(s):
n/a

Abstract:
The specific aims of this project were to study the effectiveness of ergonomic interventions for the reduction of musculoskeletal injuries/illnesses in the furniture manufacturing industry and to explore ways that ergonomic interventions can be introduced/promoted to increase the likelihood of their acceptance by the users. High-risk work tasks were identified using survey and passive surveillance techniques. Ergonomic solutions were developed in an iterative process that involved rapid prototyping techniques. Once developed, these solutions were evaluated in the laboratory for effectiveness in reducing biomechanical loading. Those solutions found to be effective in the laboratory were then field-tested for their impact on productivity and more generally, acceptability.

Impact:
Effective ergonomic interventions were engineered, fabricated, lab-tested and field tested for the furniture manufacturing industry. These included solutions for both the casegoods and upholstered furniture sectors. The evaluation of these interventions included a detailed biomechanical assessment in the laboratory to evaluate the interventions' effects on the user, as well as a formal evaluation in the field that provided important information with regard to the effects of the intervention on user productivity. To extend the results of this industry-research collaboration, Dr. Mirka worked with the American Furniture Manufacturers Association to develop the first industry-developed voluntary ergonomics guideline, which is a main component of the current ergonomics emphasis of OSHA.

Ventilation Control to Reduce Airborne Contaminants

Project Period:
1999 - 2002

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
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Peter S. Thorne
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Abstract:
This research focused on the use of real-time instruments to monitor the working environment of a swine confinement, and as a potential feedback sensor for the control of ventilation systems. Continuous recordings of temperature, relative humidity, airborne dust, and ammonia were made over a year-long period in a working swine confinement together with measurements taken by standard sampling methods. Results indicated a good correlation between the real-time temperature and humidity recordings and standard sampling methods but low correlation between sensor-based dust and ammonia measurements and those taken by standard method. These results indicate that robust sensors that are easily calibrated and capable of withstanding the harsh environment of a swine confinement are needed. Computer software capable of simulating dynamic processes was also utilized to simulate the effect of airflow on environmental and quality control parameters. The model output compared well with results obtained from the real-time measurements.

Impact:
Few options for reducing air contaminants generated in animal confinements exist. Of these, dilution ventilation is a viable option. This study demonstrated that ventilation rates affected contaminant levels. However, the harsh environmental conditions (persistent ammonia and dust levels and high humidity) indicate the need for real-time sensors that can withstand these conditions and remain accurate between service periods and therefore perform as control sensors when

regulating ventilation rates. An icon-based numerical simulation software package proved to be flexible and accurate enough to use as a method for seeking optimal minimum of flow-versus-concentration for mechanically-ventilated rooms in which a contaminant is generated.

Hearing Protector Allowing Acoustic Communication

Project Period:
1999 - 2004

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Co-Investigator(s):
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Abstract:
The overall aim of this project was the development and evaluation of an advanced hearing protective headset that combines maximal attenuation of ambient sounds with signal processing that extracts the most important components of the sound field for controlled presentation to the user. By processing the signals from a microphone array mounted on the headband of the hearing protector, this device enhanced desired signals from a specified "look" direction relative to signals from other directions, allowing improved acoustic signal reception in many high noise environments. The signal processing was also designed to allow the preservation of sound localization ability and protection against high-level sounds.

Impact:
Microphone array technology is an attractive solution to many problems of communicating in noisy places. Our work described the limitations of this technology in real-world environments. For many industrial workplaces the degree of reverberation in the environment is so high (and the distance to strong noise sources so large) that there is very little expected benefit from adaptive array techniques. Workers in outdoor environments, such as aircraft ground crews, may benefit from adaptive array technology because of the low degree of reverberation in their surroundings. Workers in very-high-noise environments will also benefit from the convenient means developed here of delivering audio signals using optical transmission.

Biomarkers of Polycyclic Aromatic Hydrocarbon Exposure among Asphalt Workers

Project Period:
1997-present

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Co-Investigator(s):
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Abstract:
Asphalt paving workers had inhalation and dermal exposure to polycyclic aromatic compounds (PAC) that differed significantly by task and was higher than exposures experienced by other highway construction workers without regular contact with hot-mix asphalt. The task-based differences in personal exposure, particularly dermal exposure, led to task-based differences in total absorbed dose, as measured by urinary 1-hydroxypyrene. Finally, the task-based differences in absorbed dose led to marginally significant differences in DNA damage, or biologically effective dose, as measured by DNA adducts. DNA adducts were found to increase throughout the workweek, a result that was not observed among non-paving workers; however, adduct levels among paving workers were not found to be significantly higher than non-paving workers. Based on the evaluation of urinary 1-OHP in these workers, control strategies should focus on reducing dermal exposure to lower total absorbed dose, which would likely decrease the extent of DNA damage.

Impact:
Our research provides important new information on the relationship between exposure, and biomarkers of absorbed and effective dose among PAH-exposed asphalt workers. While our research did not directly address the carcinogenicity of

asphalt fumes, it supplies an insight into the pathways between exposure and DNA damage as a possible indicator of cancer risk. The issue of cancer risk among occupationally exposed asphalt workers is complex. While asphalt fumes are known to contain compounds that are known carcinogens, the possible cancer risk among workers exposed at the level found in processes such as asphalt paving is uncertain. This finding, as a complement to recent studies that demonstrated excess respiratory cancer among European asphalt (bitumen) workers, provides new information that is relevant to health policy and possibly standard setting for asphalt fume exposures. As over 300,000 US workers are exposed to asphalt fume, and the number of workers exposed worldwide is in the millions, the potential public health impact of these findings is very substantial.

• Exposure Assessment Methods •

Predicting Relative Workload During Physically Demanding Work

Project Period:
2002 - 2005

Researcher Name:
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Co-Investigator(s):
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Abstract:
Expressing absolute workload as a percentage of maximum oxygen uptake (VO2max), commonly known as relative workload, is recommended by many work physiologists because it provides a subject-specific workload and enables accurate assessment of physical fatigue. The specific aim of this research is to develop a direct method to predict relative workload from in-situ collected sub-maximal oxygen uptake data without the need to determine maximum oxygen uptake. The method is developed by using data dependent systems (DDS) modeling and time series analysis techniques; a regression model between relative workload and a statistical characteristic of collected oxygen uptake data can be developed. With further development, the technique presented will be valuable in identifying excessively demanding tasks based on a more subject-specific workload.

Impact:
With further development and improvement, the relative workload prediction technique will be valuable in identifying excessively demanding tasks so the work can be better matched to the abilities of subjects. Arriving at a more robust and reliable methodology, will be instrumental for research with the following foci:

Real-Time In Situ Aerosol Monitoring in Mine Atmospheres

Project Period:
2002 - 2006

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Co-Investigator(s):
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Abstract:
The cumulative exposure of mine workers to a wide range of aerosol (soot, silica, asbestos) and associated gas-phase pollution (methane, hydrogen, polycyclic aromatic hydrocarbon) leads to long-term pulmonary disease and other health hazards. Rapid, continuous monitoring of these pollutants will allow exposure to be minimized. To this end, development and field-testing of an in situ, real-time monitor of particulate matter, and other chemical hazards, present in mine atmospheres is being undertaken. This novel instrument employs three complimentary spectroscopic techniques – elastic and inelastic (Raman) scattering as well as laser-induced fluorescence – to non-invasively probe an adjacent air column for aerosols and gases that represent an occupational hazard to miners. Optical signals from the sensor will be interpreted automatically to yield bulk chemical, size (for aerosols), and concentration information on these toxic materials.

Impact:
Although specific workplace safety and health impacts are difficult to quantify at this early stage in the project, several broader impacts have become evident. Foremost is the development of the microlaser system. The low cost and high performance of this novel design makes it ideal for application in a number of research and monitoring instruments, for methods as varied as scattering by aerosol and aqueous particles; fluorescence of organic, inorganic, and biological particulate

matter; and particulate metals analysis by a laser-induced plasma spectroscopy (LIPS) technique. This will increase worker and workplace safety specifically in the case of our in situ instrument for mines, and will contribute broadly to improvement in public health by enabling both research and monitoring technology.

Making Heat Stress Assessment Relevant Again

Project Period:
2000 - 2004

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Co-Investigator(s):
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Abstract:
Occupational heat stress occurs in hot work environments, during heavy work, while wearing protective clothing, or from any combination of these. The exposures may be routine for those in hot industries to intermittent for those in emergency response. The environmental conditions are reflected in an index called wet bulb globe temperature (WBGT). An occupational exposure limit is an upper limit on WBGT, and the limit is adjusted for work demands. This research provided adjustments for woven and non-woven protective clothing over a wide range of humidities and work demands. A curve relating WBGT to safe exposure time was generated that is protective of 95% of the people. Quantifying the resistance to cooling by sweat evaporation can distinguish among different fabrics and clothing construction. An unexpected new finding was that the resistance increases with lower humidity. This means that the predicted cooling is less than the observed cooling.

Impact:
The major impacts of this research were the Clothing Adjustment Factors as a viable accounting of protective clothing on heat stress. The results are robust to a range of humidities and metabolic rates. The Clothing Adjustment Factors are ready for immediate use. The basic paper has been presented to the ACGIH for adoption as a Notice of Intended Change in 2005. The empirical method developed with this research is based on the well-established WBGT and adapted to the Clothing Adjustment Factors. It expands the range of the widely used Navy guidance and applies to a less fit group of workers. The method will undergo some fine tuning. The determination of total evaporative resistance is a robust way to compare different clothing ensembles and provide insight to how protective clothing contributes to heat stress. The measured values can expand the use of rational models of heat stress.

Exposure Response Relationship in Hand Arm Vibration

Project Period:
2000 - 2005

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Volvo Truck Cab Plant, Umea, Sweden
Study site, hygiene/ ergonomic team

Finnish Institute of Occupatonal S&H
Field team, Suomussalmi study site

Co-Investigator(s):
n/a

Abstract:
Exposure to vibrating tools produces several characteristic disorders affecting tissues of the upper extremity, which collectively are termed the hand-arm vibration syndrome. NIOSH recognized the importance of exposure and response relationships in hand-arm vibration by identification as one of three foci of the Musculoskeletal Disease Consortium. This work is a collaboration of investigators from Canada, Finland, Sweden and the United States to study four vibration-exposed cohorts in Europe and North America. These cohorts include the Suomossalmi forest worker cohort in Finland, the Volvo truck cab assembly workforce in Umea, the Electric Boat shipyard workforce in Connecticut, and Connecticut dental hygienists exposed to high frequency vibration. Dental hygienists appear to experience rapid onset injuries to mechanoreceptors in the fingers. The three industrial cohorts have been studied and are being restudied because the proposed study period may be too brief to appreciate intra-subject change.

Impact:
Study results exceeded the expectations of the international study team, offering research direction and practical applications. This was the first instance of the use of data logging

devices for field vibration measurement. The technology transforms the approach to exposure by capturing exposure and biodynamic differences at the individual level, and altering exposure response assumptions by a factor of at least 2. The feasibility of measuring force in the field by direct sensor has applications to other studies of industrial populations. The measurement of mechanoreceptor threshold with a patented device provides a quantitative test, which appears to identify functional loss, well before symptoms occur..The resolution of the clinical (and possibly sub-clinical) components of the hand arm vibration syndrome should be within reach when this exposure response information is translated into the design of AV materials and tools.

Numerical Modeling of Size-Specific Aerosol Concentration

Project Period:
2001 - 2005

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Co-Investigator(s):
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Abstract:
Computational fluid dynamics (CFD) is a promising approach for modeling exposure, assessing control efficiency, and other occupational health problems involving inhalable and respirable particulates. Currently no verified, validated method exists for predicting aerosol concentration and size distribution fields for occupational health problems. There are also many sources of uncertainty in the use of CFD simulations, including the turbulence model selected, the boundary conditions imposed, and the conceptual model of reality input to the computer. This research will (1) provide a complimentary tool for use with CFD codes to predict aerosol concentration fields and size distributions and (2) develop and apply a methodology to evaluate uncertainties inherent in the use of this tool for occupational and environmental exposure problems. The aims are to (1) improve the existing computer algorithm to take output from computational fluid dynamics software and make predictions of size-specific aerosol concentration fields, (2) develop parallel implementations on large-scale machines to investigate convergence of the algorithm, (3) assess important sources of uncertainty in the prediction of aerosol concentrations relevant to occupational health problems, and (4) employ computational visualization tools to enhance interpretation of the results and to improve worker education.

Impact:
A major impact is identification of the bias in steady simulations of aerosol exposure based on the orientation effect. The work is also the first, to our knowledge, to provide quantification of numerical uncertainty for simulations of size-specific aerosol exposure. This will provide guidance for future simulations of such exposures. One potential impact is that the use of CFD models for aspiration efficiency studies may replace wind tunnel studies especially at air velocities more representative of actual occupational environments and at the larger particle sizes. However, perhaps the most significant impact is the advancement of CFD as a tool to predict the actual inhaled dose, a metric superior to exposure with regard to health outcomes.

Pesticide Dose Monitoring in Turf Applicators

Project Period:
2002 - 2005

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Charlene Crawley, PhD.
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James Mays, PhD.
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Abstract:
One of the greatest barriers to obtaining useful results in epidemiologic studies is the lack of adequate exposure data. This study was designed to evaluate the total body dose of commonly used pesticides using urine biomonitoring. These data will be used for an external validation of a statistical model that was developed to predict pesticide dose in professional turf applicators. Urine samples (complete 12 and 24 hour) were collected from approximately 125 workers from 6 different branches of a nationwide lawn care company, and information concerning pesticide use patterns, and hygienic and behavioural factors, was collected. Total body dose will be estimated and the variables that are effective in

predicting total body dose will be identified. A previously developed quantitative exposure prediction model, based on use records and other predictor variables, will be validated and new models will be developed as necessary.

Impact:
Based on the newly collected data, the only known pesticide dose and exposure prediction model for professional turf applicators can be validated and new models can be developed, if necessary, to better predict pesticide exposures in an occupational setting. Upon completion, this study will result in a significant refinement of pesticide dose estimation for epidemiologic research, which will allow for the identification of health risks that would not otherwise be found using traditional methods of exposure assessment. In the short term, results from this study can be used to reduce pesticide exposures by identifying cost-effective controls in both occupational and environmental settings. In the long term, this research may help reduce both acute and chronic health risks.

Statistical Problems in Occupational Safety and Health

Project Period:
2000 - 2004

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Co-Investigator(s):
n/a

Abstract:
The technology for monitoring occupational exposure depends crucially on the statistical analysis of the exposure data. Many of the problems here are quite different from the problems addressed in the mainstream statistics literature, and available in popular statistical software. Motivated by this, novel methodologies have been developed for analyzing occupational exposure and pollution data. A statistically rigorous criterion has been proposed for establishing the equivalence of an alternate sampling device to the OSHA standard. A thorough investigation has been carried out on tolerance intervals for assessing whether workplace exposure levels are within permissible limits. Considerable progress has been made on the development of a strategy to handle exposure data below the detection limit. Necessary computational algorithms have also been developed to implement the newly developed procedures.

Impact:
The statistical methods that have been developed are simple and accurate, and are also cost effective since they are applicable to small samples. The completed research has resulted in valid and improved methods for exposure data analysis, and the techniques can be effectively used to analyze data and assess workplace exposure levels periodically. The completed work has also highlighted the deficiencies and inaccuracies of some of the widely used current approaches. For example, for exposure samples that include values below the detection limit (DL), the conventional method of replacing the below DL values by DL/2 etc can be very inaccurate. The considerable effort and funds required to obtain exposure samples, and the impact of the resulting conclusions, call for the use of accurate and appropriate methodologies for analyzing the data.

Use of Action Research Methods for Targeted Intervention Evaluations in (TIE-IN) Construction

Project Period:
1999 - 2004

Researcher Name:
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CPWR

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South Jersey Building and Construction Trades Council

Co-Investigator(s):
Vicki Bor
Sherman, Dunn, Cohen, Leifer & Yellig

Abstract:
Construction is among the most hazardous industries in the U.S. However, it is organized in such a way that makes intervention research particularly challenging. Interventions which actively enlist the participation of those within the industry well positioned to influence change are more likely to have a lasting impact on improving safety and health conditions. We used participatory research methods to define an intervention focus and strategy with a local building trades council. They defined silica, asbestos and other dusts, and training of union representatives on how to address these hazards as our intervention focus and strategy, respectively. Hazard Information and Action Packets were developed and introduced as part of training workshops. Course evaluations were generally very favorable. Pre- and post- intervention questionnaires completed by workshop participants showed statistically significant improvement at the 95% confidence level in questionnaire scores for both groups (pre-workshop and post-workshop) and individuals.

Impact:
Training instructors and union representatives from twelve different local union and training organizations were represented at the workshops convened on May 19, 2004 and on June 30, 2004. As part of this process, the South Jersey BCTC established a safety and health committee to guide our research. Participants in this intervention represent thousands of workers in southern New Jersey. Although it is difficult to measure the direct impact of our efforts, it is likely that participants utilized the information they gathered (through both print and verbal communication) to more effectively address silica and asbestos exposures routinely encountered in this geographic region. In addition, networks were established between CPWR, local unions, Hunter College and government agencies, which will facilitate future research endeavors aimed at improving occupational safety and health conditions in construction.

Application of a Task-Based Exposure Assessment Model (T-BEAM) To Construction Safety and Health Programs, Education and Training

Project Period:
1995 - 2005

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International Masonry Institute

International Union of Painters and Allied Trades

International Union of Bricklayers and Allied Crafts

Philadelphia Building and Construct

Co-Investigator(s):
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Mike Flynn, PhD
University of North Carolina

Steve Rappaport, PhD
University of North Carolina

Jim Tsafos, PhD
Drexel University

Abstract:
Construction workers are at high risk of exposure to silica, metal fumes and dusts, and a number of other hazardous agents. NIOSH estimates that at least 1.7 million workers may be exposed to respirable silica and that many are exposed at levels exceeding current standards (NIOSH, 1991). Beginning in 1993, CPWR created and pioneered the use of "T-BEAM" (Task-Based Exposure Assessment Model). The characteristic properties of the T-BEAM approach are the active involvement of journeymen in the exposure assessment process and an emphasis on the identification and evaluation of effective engineering controls. This project utilized the T-BEAM model to characterize silica exposures among construction trades with and without use of engineering controls. We have documented high probabilities of exceeding recommended exposure limits for silica among sampled trades (bricklayers, painters, operating engineers and laborers). In addition, a pilot educational program for utilizing journeymen workers for ongoing hazard prevention in construction was developed.

Impact:
As part of this project, an Engineering and Work Practice Controls Work Group, co-chaired by CPWR and NIOSH, has been established. This group, made up of labor, government, industry representatives and researchers has been a catalyst for driving engineering controls research in construction beyond this project. Research data generated by this project has been utilized in a number of ways likely to have an impact on reducing exposure risk in construction. The Building and Construction Trades Department (BCTD), AFL-CIO used T-BEAM data for support to OSHA rulemaking efforts related to silica. The International Union of Bricklayers and Allied Crafts Union has used information from T-BEAM to promote collective bargaining agreement language which requires use of water and/or local exhaust ventilation when cutting and/or grinding masonry, and to assist in passage of a law which restricts dry cutting and grinding of masonry without use of engineering controls.

Dermal Particle Exposure and Granulomatous Disease

Project Period:
2001 - 2004

Researcher Name:
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NIOSH

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Co-Investigator(s):
n/a

Abstract:
We hypothesized that skin exposure to beryllium particles would provide an alternative route for sensitization to this metal. We employed optical scanning laser confocal microscopy and size-selected fluorospheres to demonstrate that 0.5- and 1.0-μm particles, in conjunction with motion, as at the wrist, penetrate the stratum corneum of human skin and reach the epidermis and, occasionally, the dermis. In addition, topical application of beryllium to C3H mice generated beryllium-specific sensitization that was documented by peripheral blood and LN beryllium lymphocyte proliferation tests (BdLPT) and by changes in LN T-cell activation markers, increased expression of CD44, and decreased CD62L. These data are consistent with development of a hapten-specific, cell-mediated immune response following topical application of beryllium and suggest a mechanistic link between the persistent rate of beryllium worker sensitization and skin exposure to fine and ultrafine beryllium particles.

Impact:
These studies helped define the need for control of dermal exposures in work environments with elevated submicrometer particulate levels and provided biological support for the development of engineering control strategies. As a direct result of this work, increased efforts have been made in the workplace to protect workers from dermal contact with beryllium. This has directly resulted in a very significant decrease in the number of workers in the beryllium industry that develop sensitization to beryllium.

Molecular analysis of mycobacteria in cutting fluids

Project Period:
2001 - 2004 (+ 1 year no-cost-extension)

Researcher Name:
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Key Partner(s):
Milacron, Inc.

Co-Investigator(s):
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University of Cincinnati

Abstract:
Microbial contaminants including nontuberculous mycobacteria (NTM) in metalworking fluids (MWFs) have been implicated in occupational respiratory illnesses in machine workers. The project involved development and application of modern DNA-based approaches for efficient monitoring of mycobacteria (culturable and non-culturable) in MWF. The work led to (i) development of Mycobacteria-specific polymerase chain reaction (PCR)-based protocols for real-time detection and quantitation of mycobacteria in water-based MWF; (ii). PCR screening of field samples of different commercial formulations of water-based MWFs for presence of mycobacteria followed by species-specific and strain-specific identification of the cultured isolates using optimized molecular typing methods; (iii) investigation of the loss of viability of the mycobacteria in MWF versus saline and dose-response relationships using different biocides. The developed state-of-the-art DNA-based methods will allow an effective and early monitoring of metalworking fluids for presence of mycobacteria and thus help assess and minimize worker exposure to mycobacteria via MWF in an occupational setting.

Impact:
The study led to the optimization of mycobacteria-specific PCR protocols for real-time detection and quantification of mycobacteria in metalworking fluids (MWF) without culturing. Analytical laboratories in this business (e.g. Biosan, Inc., MI) have initiated efforts for adopting the PCR protocols in their MWF analysis for industrial clients to achieve more reliable results on mycobacteria particularly when they are non-culturable. Our real-time PCR protocols were well received at ASTM symposium (December, 2004) on 'Recovery and Enumeration of Mycobacteria in MWF Environment' and based on our recommendation, a task force has been set up to validate this technique using blinded samples in order to adopt it as an ASTM standard protocol. Our direct cell-lysis based PCR protocol was adopted for clinical studies on TB in a Taiwan study. Besides revealing multiple genotypes of

MWF mycobacteria, our work will serve as a reference for future epidemiological studies and as test strains for biocide efficacy testing.

Quantification of the environmental UVA exposure

Project Period:
2004 - 2009

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Abstract:
Humans are exposed to ultraviolet radiation in their normal day-to-day lives. Much research has been conducted into the impact of exposure to UVB radiation (280 –320nm), while research into the impact of exposures to UVA radiation (320 – 400 nm) is gaining momentum. Exposures to UVA radiation have been linked to increasing the risk of skin cancer, premature skin photoaging and skin wrinkling. Unlike UVB radiation, UVA radiation is transmitted through material such as window glass found in offices and homes. Accordingly, humans are exposed to this radiation in environments where UV exposure is not normally associated (indoors). This work involves a prototype UVA dosimeter that is responsive to the UVA wavelengths only, and does not respond to the UVB wavelengths and ways in which this doismeter can be used to assess personal UVA exposure.

Impact:
As this project is in its infancy, judging the impact is difficult. I have, however, had a great deal of public interest in this project through the media release of initial results of the development of a UVA dosimeter. During March 2005, I have had television coverage on a Australia-wide morning TV program as well as articles in National and State newspapers outlining this project and how the results gained will help Occupational Health and Safety research.

Microbiological Air Contamination from Machining Fluids

Project Period:
2001 - 2004

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Cimcool

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Abstract:
Workers exposed to machining fluid aerosols may have an increased risk in developing a variety of respiratory and skin diseases, such as allergies, asthma, hypersensitivity pneumonitis, and dermatitis. About 1.2 million workers in the United States are occupationally exposed to metalworking fluids (MWFs). Microbial contamination of water-based MWFs is one of the suspected causes for respiratory diseases but the exposure-response relationship is not well understood. One reason for this knowledge cap is that insufficient information has been available so far on the composition and concentration of airborne microorganisms at metalworking sites. We have studied the aerosolization of microorganisms and mist with a laboratory-scale set-up, which allows investigating one variable at a time.

Impact:
The results indicate that the estimation of workers' exposures cannot be based solely on the analysis of bulk MWF as there are differences among microorganisms in their aerosolization potential. The microbial fragments cannot be detected by traditional microbiological methods, cultivation and microscopic counting. To fully understand the workers' exposure to microbial contaminants in MWF environments, sampling and analysis methods have to be modified to account for microbial fragments. This will include collection of particles with methods that are efficient below the size range of intact microbial cells (for example filter sampling or low-pressure impactors) and analysis of the samples with methods that can detect microbial fragments (for example LAL assay for endotoxin and ß-glucan, or immunochemical assay for microbial allergens).

For fluid maintenance, it is not enough to kill the microorganisms by using a biocide. More importantly, the total microbial biomass in the fluid needs to be kept under control in order to prevent the aerosolization of microbial fragments.

Application of a Task-Based Exposure Assessment Model (T-BEAM) To Construction Safety and Health Programs, Education and Training

Project Period:
1995 - 2005

Researcher Name:
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International Union of Painters and Allied Trades
International Union of Bricklayers and Allied Crafts
Philadelphia Building and Construct

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Steve Rappaport, PhD
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Jim Tsafos, PhD
Drexel University

Abstract:
Construction workers are at high risk of exposure to silica, metal fumes and dusts, and a number of other hazardous agents. NIOSH estimates that at least 1.7 million workers may be exposed to respirable silica and that many are exposed at levels exceeding current standards (NIOSH, 1991). Beginning in 1993, CPWR created and pioneered the use of "T-BEAM" (Task-Based Exposure Assessment Model). The characteristic properties of the T-BEAM approach are the active involvement of journeymen in the exposure assessment process and an emphasis on the identification and evaluation of effective engineering controls. This project utilized the T-BEAM model to characterize silica exposures among construction trades with and without use of engineering controls. We have documented high probabilities of exceeding recommended exposure limits for silica among sampled trades (bricklayers, painters, operating engineers and laborers). In addition, a pilot educational program for utilizing journeymen workers for ongoing hazard prevention in construction was developed.

Impact:
As part of this project, an Engineering and Work Practice Controls Work Group, co-chaired by CPWR and NIOSH, has been established. This group, made up of labor, government, industry representatives and researchers has been a catalyst for driving engineering controls research in construction beyond this project. Research data generated by this project has been utilized in a number of ways likely to have an impact on reducing exposure risk in construction. The Building and Construction Trades Department (BCTD), AFL-CIO used T-BEAM data for support to OSHA rulemaking efforts related to silica. The International Union of Bricklayers and Allied Crafts Union has used information from T-BEAM to promote collective bargaining agreement language which requires use of water and/or local exhaust ventilation when cutting and/or grinding masonry, and to assist in passage of a law which restricts dry cutting and grinding of masonry without use of engineering controls.

• Fertility & Pregnancy Abnormalities •

Endocrine Disrupting Chemicals and Thyroid Outcome

Project Period:
2003 - 2007

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Co-Investigator(s):
n/a

Abstract:
This study will examine long-term and recent fish consumption in an existing, well-characterized cohort of approximately 3,600 frequent and infrequent Great Lakes sport fish consumers and will expand biomonitoring from the original members of the cohort to include 500 additional members. Dietary exposure to PCBs may co-vary with exposure to related chemicals such as PBDEs and DDE. The effects of these chemicals on thyroid hormone balance will be determined and the impact of reproductive health and other potential confounding variables on these relationships characterized.

Impact:
After exposure assessment and health outcomes have been analyzed, this research may provide direction for sport fish advisories and a better understanding of interactive effects of endocrine disrupting chemicals in human populations.

Dioxins, Male Pubertal Development and Testis Function

Project Period:
2002 - 2007

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Abstract:
The objective of this project is to investigate the relationships between dioxins and male reproductive tract malformations, male pubertal development and alterations in testis function. We hypothesize that pre-puberty adolescent dioxin levels are associated with disturbances in physical growth, sexual maturation (age of onset and tempo), and adult testis function.(specifically alterations in reproductive hormones and semen quality). We also hypothesize that in utero levels of dioxins are associated with alterations in physical growth and sexual maturation in boys. In utero dioxin levels will be estimated using the child's current serum dioxin level, as well as historical reproductive (e.g., breast feeding) and residential information. In addition, the study will investigate whether in utero levels of dioxins are associated with reproductive tract abnormalities (specifically hypospadias and cryptorchidism).

Impact:
This project contributes to a better understanding of the science underlying the effects, exposure, assessment, and management of endocrine disruptors; and the extent of the impact of endocrine disruptors on humans. Specifically, this research is helping to: (1) characterize the effects of exposure to multiple endocrine disruptors (mixed dioxins); (2) characterize the critical biological factors during development resulting in toxicities later in life; (3) determine the extent to which exposure to endocrine disruptors contribute to the onset or increase in the severity of diseases; (4) evaluate exposure methods, measurement protocols, and models; (5) determine whether adverse developmental and reproductive effects are occurring in human populations following exposure to endocrine disruptors; (6) determine sources of exposure and environmental fates of endocrine disruptors; and (7) evaluate existing testing guidelines for their adequacy to evaluate endocrine-mediated effects.

Biochemical Markers of Sperm Maturity And Function: Next Day Assessment In Shipped Semen

Project Period:
2002 - 2007

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n/a
Co-Investigator(s):
n/a

Abstract:
We have successfully developed conditions for preservation of various sperm attributes for shipping, including sperm concentrations; HspA2 chaperone protein levels; immunocytochemistry of individual sperm by both creatine kinase antibody, to detect cytoplasmic retention, and by HspA2 antibody to demonstrate the proportion of mature sperm; DNA nick translation, which highlights the proportion of sperm with DNA fragmentation; fluorescence in situ hybridization (FISH) to detect chromosomal disomy and diploidy; aniline blue staining, which reflects chromatin maturity in individual sperm; and objective morphometry of various sperm regions, including the head and tail. The utilization of sperm biochemical markers provides an excellent opportunity to overcome the shortcomings of using conventional semen parameters. The biomarkers allow the early detection of declines in sperm

maturity due to disturbed spermatogenesis or spermiogenesis as a consequence of exposure to reproductive toxicants. Such dynamic and objective biomarkers have not previously been available.

Impact:
All the data, which further strengthen the concept of objective biochemical markers, have been discussed in more than 35 national and international meeting presentations, and in our 19 manuscripts which have been either published or are in the publication process in the past 5 years. Based on relationships between sperm maturation and levels of various nuclear and cytoplasmic markers that we have identified, we believe that these sperm biochemical markers could be used as reliable early indicators of toxicant effects on testicular function and/or sperm maturation resulting from occupational or environmental exposure.

Male Reproductive Effects from Occupational Exposure to Boron

Project Period:
2001 - 2006

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Co-Investigator(s):
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Abstract:
Moorman et al identified boric acid as a high priority chemical for occupational field study. To address this, a three phase epidemiologic investigation is being conducted in China where extremes of workplace boron exposure occur. Aims of the study are to describe relationships between boron exposure and male reproductive health. The first phase utilized community-based participatory methods to develop culturally appropriate study materials and train a strong local research team. Data was collected from workers and controls on health, lifestyle, diet, and work habits. Work practices were observed in five mines / processing plants. Environmental sampling of soil, air, and water was conducted. In phase two, biological monitoring of 69 participants led to a design strategy and SOPs for the final phase. Currently, interview data from >1300 boron workers and controls as well as more than 1400 biologic samples (blood, urine, semen) are being analyzed for associations between boron exposure and male reproductive endpoints.

Impact:
This research links workplace boron exposure, boron food and water exposure, biomonitoring data, and reproductive health endpoints. Findings from this comprehensive data set will be used to guide governmental and non-governmental entities in establishing policies that protect reproductive health for workers exposed to boron-containing compounds. In addition, two important secondary gains of the research occurred during the course of the study. First, substantial improvements in health and safety conditions were undertaken in five plants under study as a result of increased awareness and collaborative efforts on the part of plant owners and workers. Second, local officials in this NE region of China were mentored in occupational health research techniques. The local officials also had the opportunity to see Chinese academicians and their doctoral students, Chinese government officials, and US researchers collaborate in order to demonstrate a commitment to worker health and safety, a factor of importance to global workplace health and safety.

• Health Services Research •

Distributed Occupational Knowledge System

Project Period:
1999 - 2002

Researcher Name:
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Co-Investigator(s):
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Abstract:
Occupational health receives too little attention in primary care settings; in addition, public health surveillance acquires and utilizes too little of the information available in clinical settings. Obtaining an appropriate occupational history requires both time and expert knowledge about occupational medicine, both of which are inadequate in most primary care settings. The DOKS (Distributed Occupational Knowledge System addresses these problems by developing a computer assisted system, which may be directly incorporated in routine primary health care delivery. It obtains a computer assisted occupational history and makes case-specific recommendations for preventive interventions. It will also systematically collect clinical information for public health analysis. The system was implemented in three different health ambulatory care settings: county hospital based, health maintenance organization, and clinic group. Initially, interviews were in person, then by phone, and later by computer. Recommendations were provided to patients and clinical care providers. Evaluation includes historical and concurrent controls and is based on exit and 3 month interviews and record review. The process also yielded valuable surveillance data including population segments often missed by other methods and describing functional impact of work rather than just occupationally caused disease.

Impact:
The investigators hope that this project will facilitate recognizing the high frequency of the impact of work upon health and of health upon work. In addition, the work should facilitate improved occupational health surveillance and computer systems.

• Hearing Loss •

Noise, Solvents, and Hearing Loss

Project Period:
2002-2005

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Alcoa Inc.

Abstract:
This project is a longitudinal study of solvent and noise exposures and hearing loss in an industrial cohort. We are currently completing the analyses to determine whether solvent exposures significantly affect the risk of high frequency hearing loss.

Impact:
We expect to impact the way that industries view noise exposure and its relationship to hearing loss risk. We also hope to shed light on the role of chemical exposures in hearing loss risk.

Occupational Hearing Loss in Washington State

Project Period:
1999-2003

Researcher Name:
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Key Partner(s):
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Pacific Hearing Conservation

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Washington (State) Dept of Labor & Industries

John Stebbins, MS CIH
Washington (State) Dept of Labor & Industries

Robert Leo, MS
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Abstract:
Occupational hearing loss (OHL) is a common problem. We surveyed 771 individuals with recent OHL claims, and we evaluated noise exposure and hearing loss prevention efforts at 76 companies in eight industries with different rates of OHL claims. Our goal was to determine whether claims information is useful to "target" industries or companies for interventions to reduce risk for illnesses – such as OHL – that manifest after years of exposure to a hazard. Claim filing was strongly influenced by factors other than illness severity and work factors. Excessive noise was common in all industries. Most companies had shortcomings in hearing loss prevention programs. Claims statistics and claimant reports did not reliably identify industries or companies with greater risk for OHL, although this information might be useful with other

information. The industries with greatest margin for improvement are not necessarily the noisiest industries, but industries where noise exposure is moderate or intermittent.

Impact:
Based in part on study findings, the Washington State OSHA is conducting a "noise in road construction" special enforcement program. We have received funds to evaluate that program. Using the evidence base from this study, and in collaboration with SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) of western Washington, we drafted a guidebook, Occupational Noise Exposure and Hearing Loss Prevention, for sheet metal manufacturing companies. Similar guidebooks are in preparation for other industries evaluated in the study. SMACNA and the Sheet Metal Workers union are aiding our proposal for a group randomized, controlled intervention trial to assess a different approach to hearing conservation training, focusing on management training in addition to usual annual employee training. The training would incorporate the hierarchy of safety colors and signal words for ten-decibel bands of noise and straightforward hearing protection guidelines, as presented in the evidence based guidebook.

Prospective Study of Hearing Damage Among Newly Hired Construction Workers

Project Period:
1999-2004

Researcher Name:
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Puget Sound Area Construction Safety Summit Steering Committee

Co-Investigator(s):
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Sharon Kujawa
Massachusetts Eye and Ear Infirmary; Harvard University

Abstract:
Noise exposure and hearing loss is widely recognized in the construction industry but has not been comprehensively studied. Furthermore, the way in which hearing damage develops during the first years of exposure has not been characterized. We enrolled a group of 393 construction workers from 8 trades at the start of their apprenticeship and 63 unexposed student controls, and followed them over four years. Each subject received annual hearing tests (audiometry and Distortion Product Otoacoustic Emissions, (DPOAEs)), questionnaires, and noise measurements. Noise exposure levels varied widely between trades and exceeded 85 dBA (using NIOSH measurement criteria) in about 67% of work shifts. Over an average of 2.4 years of work in construction, there was a measurable decrease in DPOAEs of about 0.5 dB per year at 4 kHz. No comparable change was observed using audiometry.

Impact:
This study has generated a tremendous amount of new information about noise exposure and hearing loss risk among the construction trades. The information includes trade and task-specific noise levels, the contribution of non-occupational noise to a typical construction worker's total exposure, the effectiveness of hearing protection device use in construction, and hearing levels and the rate of change of hearing among young construction workers. In addition, the study has addressed several scientific issues of importance for continuing research including the accuracy of task-based exposure assessment techniques, the ability of construction workers to recall their tasks and exposures over time, the variability of DPOAEs over time, and the relationship among various different noise exposure measurement techniques (metrics). The wide range of the information has been disseminated to voluntary and regulatory agencies through provision of testimony to the construction industry and to hearing protector manufacturers.

Models for Assessing Risk of Occupational Hearing Loss

Project Period:
1997-2006

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Caroline Gearhart
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Co-Investigator(s):
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Abstract:
Hearing loss is the most common occupational disease in the United States, and consequently it has been identified by NIOSH as a priority area in the National Occupational Research Agenda. More than 30 million workers are exposed to potentially hazardous noise and 9 million are exposed to other ototoxic hazards. Noise is identified as a prominent factor in approximately 10 million individuals in the United States with hearing impairments, and occupational exposures remain a critical source of chronic noise. There remain significant knowledge gaps concerning factors causing noise-induced hearing loss (NIHL). One such knowledge gap concerns potentiation of NIHL by simultaneous exposure to chemical agents. This study will determine mechanisms by which chemicals can potentiate noise-induced hearing loss using a laboratory animal model.

Impact:
Chemical contaminants that interfere with intrinsic antioxidant pathways render the inner ear more vulnerable to injury from noise. Initiation of reactive oxygen species (ROS) appears to result from noise exposure. Intrinsic antioxidant pathways, when competent, can protect the ear from impairment. With promotion of oxidative stress occurring due to chemical disruption of antioxidant pathways, added noise can result in oxidative stress leading to impaired auditory function. This is true even when relatively low levels of noise are used and when the chemical agent alone does not produce hearing loss. This study facilitates prediction of chemical agents that are able to potentiate NIHL.

Development of a school-based hearing conservation program for use in rural areas

Project Period:
2002-2005

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Co-Investigator(s):
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Abstract:
A high prevalence of hearing impairment exists in rural areas, and substantial impairments appear in adolescence and early adulthood. Adolescents who work on farms or in agribusiness are at a greater risk of hearing impairment than their peers. Training in hearing protection habits is needed before the onset of hearing impairment, and school systems represent a logical place to address this need. This project developed and evaluated four hearing conservation programs-two for children in the fourth grade and two for children in the seventh grade. For each grade level, basic and comprehensive interventions were developed. The basic program included audiometry, earplugs (grade 7 only) and individual counseling; the comprehensive programs added classroom presentations, teacher resources, home activities, earmuffs (grade 7 only), and booster interventions. The comprehensive programs were informed by the Health Belief Model (HBM).

Impact:
Recipients of the comprehensive intervention reported reduced exposures to firearms, which are a common and potent risk factor in the rural population. These participants also reported increased awareness of all terrain vehicle noise as a risk factor for hearing impairment. Participants retained HLP knowledge approximately one year after the message was introduced. The finding that nearly all participants were aware of the association between noise and hearing impairment implies that hearing conservation programs should focus on effective responses to noise exposure rather than on awareness that excess noise exposure is hazardous. This implication is equally relevant for programs targeted at older members of the rural population.

• Indoor Environment •

Health Effects of Exposures to VOCs, Ozone and Stress

Project Period:
1999 - 2002

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University of Medicine and Dentistry of New Jersey
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University of Medicine and Dentistry of New Jersey

Abstract:
This study determined the effects of a psychological stressor, negative affect, and odor intolerance on responses of women to a mixture of volatile organic compounds with and without ozone. One hundred thirty healthy women were exposed to three conditions: VOCs, VOCs with ozone (VOC+O), and ambient air with a one minute spike of VOCs (MCA). Exposure to VOCs with and without ozone did not result in significant subjective or objective health effects. Combining VOCs with ozone at a low ventilation rate (~ 2 air exchanges per hour) was successful in producing irritating compounds. However, subjects' ratings of symptoms were indistinguishable between the VOCs + O and the VOCs conditions. Psychological stress significantly increased salivary cortisol and symptoms of anxiety. Lung function and neurobehavioral performance were not compromised by exposure to VOCs or VOCs + O and markers of nasal inflammation were not induced. Regardless of exposure condition, subjects high in negative affect who performed the stressor reported significantly more anxiety than those low in negative affect. Chemical intolerance did not significantly affect symptoms or markers of nasal inflammation.

Impact:
Potentially irritating gases and particles will be produced in buildings with low ventilation rates, mixtures of volatile chemicals, and ozone. However, the odors associated with these mixtures appear to be the most salient factor in the resultant complaints of building occupants. These odors are rated as unpleasant and intense, but physical symptoms and signs were not increased above those observed when the odor of the volatile chemicals was present but at a much lower concentration. Therefore, workers with exposures such as ours are probably not at increased health risk but probably will find their working environment more unsatisfactory and annoying. Furthermore, psychological stress contributes to symptoms of anxiety, which may be mistaken for physical symptoms associated with poor indoor air.

Ultraviolet Germicidal Irradiation in HVAC Systems: Effect on Worker Health and Well-being

Project Period:
1999 - 2001

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Co-Investigator(s):
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Abstract:
Microbial contamination occurs in heating, ventilation, and air-conditioning (HVAC) systems of most modern office buildings and may result in specific building-related outbreaks if heavy contamination occurs. This study evaluated the impact of UV lights on reducing microbial levels in buildings. Workers were asked to rate their satisfaction with the indoor environment, report symptoms, occurrence of respiratory tract infections, sickness absence, and complete typing tests. Extensive measures of airborne and surface bacteria, fungal spores, and viable fungi were measured at work sites and in the HVAC systems.

Impact:
We believe these findings should prompt more widespread use of UVGI as a method of source control wherever air conditioning is employed in central ventilation systems. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Building Owners and Managers Association (BOMA) have expressed interest in the findings, but to date no recommendations have emerged. We are aware of ongoing follow-up research studies by other groups of investigators in the US and in Europe. If these results confirm our findings, then authoritative agencies are expected to recommend UVGI for air-conditioning systems within mechanically ventilated office buildings throughout North America.

Prevention of IEQ Related Absence – An Intervention Study

Project Period:
1998 - 2002

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Co-Investigator(s):
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Harvard University
Matt Wand, PhD
HSPH
Michael Walters, ScD
Polaroid Corp

Abstract:
Previous observational studies found that increasing outdoor air supply rates were associated with reduced work absence among office workers. We conducted an intervention study to examine potential causes for this observation. We found that increasing CO2 concentration, a marker for lower outdoor air supply rate, was associated with increasing probability of airborne rhinovirus detection. During the intervention, the highest CO2 concentrations achieved in office buildings was equivalent to the low CO2 concentrations in prior observational studies. Thus, all outdoor air supply conditions (high and low) in the new study were much higher than in previous studies and no effect on absence was seen at these rates. A mathematical model was developed to allow estimation of airborne infection risk from simple CO2 monitoring data. This model suggests that the high outdoor supply rates in the intervention study reduced airborne infection risk for rhinovirus to negligible levels.

Impact:
This project's report that rhinovirus in office building air increased with CO2 concentration and that an identical virus was isolated from an office worker and from air in the office building was the subject of an editorial accompanying publication, a perspective in the New England Journal of Medicine, and received significant news coverage. This timely work resulted in numerous consultations with the CDC in regard to the risk of airborne infection from bioterrorist attacks. This study resulted in increased attention to the need for air disinfection techniques to prevent airborne disease transmission while conserving energy. Our data suggest that the threshold indoor CO2 concentration above which infections, including the common cold and influenza, will spread is significantly lower than currently allowed by building codes and ASHRAE standards. Additional studies of airborne infection transmission in crowded work environments, and especially in schools, are needed to confirm these findings.

An Indoor Environment Design Tool for Entire Buildings

Project Period:
2001 - 2004

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Co-Investigator(s):
n/a

Abstract:
Indoor environment is important to workers' health and welfare. Poor indoor environment design has cost billions of dollars as a result of the lost productivity of the working American. This study developed an integrated design tool with three major components: building models; a heating, ventilating, and air-conditioning model; and mass and heat source/sink models. The building models use a simplified computational-fluid-dynamics model to calculate indoor air quality (IAQ) and thermal comfort in a single zone and multi-zone model to link zones for an entire building. The integrated design tool is validated by experimental data obtained in a building and can be used to evaluate IAQ and thermal comfort in terms of contaminant concentrations, the mean age of air, ventilation effectiveness, airflow pattern, air velocity, air velocity fluctuation, air temperature, relative humidity, percentage of dissatisfied people due to draft, and percentage of predicted dissatisfied people in an entire building.

Impact:
This study opened a new field of simulation technology that will be able to replace tedious and expensive field measurements in the future building design and mitigation of IAQ problems. Simulations can be a powerful tool for design of health environments and collection of data on long-term occupant exposure. Nevertheless, we are just starting this development and a lot of research work needs to be done. Our study is one of the first ones to produce this comprehensive simulation technology and absolutely the first one to do on-site validation. The principal investigator was invited to give several lectures on the state-of-the-art technology resulting from this project. A new course was developed at the Penn State University for the students who will design our buildings. The current course is using a primitive version of the coupled program because the technology is not yet mature enough for application in the first cost- driven industry.

• Infectious Diseases •

Body Substance Exposures: Risk Factors and Psychological Impact

Project Period:
2002 - 2005

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Abstract:
Body substance exposures pose to healthcare workers a significant risk of blood-borne pathogen transmission. We examined the cost-effectiveness and the effect on exposure rates of three safety devices in a multi-hospital system. We evaluated organizational factors that affect risks of exposure with a survey of work schedules and practices of exposed workers, in a case crossover design. We are using validated psychiatric assessment tools to assess the psychological impact of sustaining an exposure both immediately and one month after the event. I have worked closely with my sponsors: Dr. Victoria Fraser, an expert in hospital epidemiology and healthcare worker safety, and Dr. Bradley Evanoff, an occupational health specialist. In addition, I will complete the MPH degree. This research, classes, and mentorship will assist my development into an independent investigator studying infectious risks to healthcare workers and designing and implementing interventions to improve the occupational health and safety of healthcare workers.

Impact:
Based on our findings about the impact of safety devices, our hospital is carefully following changes in injury rates following the introduction of each new safety device to be sure that it has a positive impact on injury rates. Our research on work schedule factors will advance knowledge about organizational risk factors for needlestick injuries. This knowledge may be used to structure work schedules and hand-offs of responsibilities at shift changes. Our research on the psychological impact of body substance exposures will advance knowledge about how healthcare workers are affected by these common events and how to identify workers at high risk for more distress. Those workers might benefit from more counseling at the time of the exposure.

Blood-borne Pathogen Risk in Non-Hospital Based Healthcare Workers

Project Period:
2002 - 2004

Researcher Name:
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New York State Public Employees Federation
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New York State Nurses Association
Co-Investigator(s):
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New York Academy of Medicine, Epidemiology
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Abstract:
The purpose of this three-year epidemiological study of registered nurses (RNs) employed in a wide range of non-hospital care settings was fivefold: first, to determine the rate of blood/body fluid exposure incidents; second, to characterize and assess exposure incident risk factors; third, to compare risk factors, rates of injury (using a measure of person time as the denominator), and availability/use of safety devices between a sub-set of non-hospital and hospital based RNs with similar responsibilities; fourth, to identify barriers to the adoption of safe work practices (i.e., Standard Precautions [SP]); and fifth, to identify opportunities to reduce the risk of exposure incidents in non-hospital-based RNs.

Impact:
These data indicate that non-hospital based RNs are a population at risk, with exposure rates that approximate those of hospital-based workers. Lack of access to on-site infection control and employee health expertise may be related to their sub-optimal formal exposure reporting. The high rate of vaccination, while reassuring, does not lessen our concern regarding these workers since they may well be exposed to other blood borne pathogens, such as HCV. Data have been presented to leadership at the collaborating partners and to the various non-hospital agencies, and a national conference highlighting the risk in this population of HCWs is planned for 2006.

A Case-Crossover Study of Sharps-Related Injuries

Project Period:
2002 - 2006

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Co-Investigator(s):
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University of Maryland
Gary S. Sorock
Johns Hopkins University

Abstract:
In our initial application we proposed to conduct a case-crossover study of 1,000 healthcare workers who sustain a sharps-related injury recruited from six hospitals in Boston and Baltimore, in order to identify factors that serve as acute precipitants of sharps-related injuries. At the time of writing 525 interviews have been completed and the number of study centers has expanded from two to 8 hospitals. The study has provided a unique opportunity to quantify risks associated with common workplace-, worker-, and device-associated factors that precipitate sharps related injuries in healthcare workers. The study size has also permitted analyses of subgroups of healthcare workers, including nurses, surgeons and trainees, while the questionnaire process has provided a wealth of data on demographics, behaviors, and beliefs of injured healthcare workers. As a result of this effort, understanding of the epidemiology of sharps-related injuries in U.S. healthcare workers has been advanced.

Impact:
Our identification of novel factors that precipitate sharps-related injuries has advanced knowledge in this area. This new knowledge is now starting to be disseminated, through presentation at national meetings and through publication of manuscripts, and also through secondary dissemination as these studies are assimilated and cited by others interested in sharps injury prevention. For example, discussion of distraction and rushing as precipitants of sharps-related injuries now appears on the website "RNweb.com" (http://rnweb.com/rnweb/article/articleDetail.jsp?id=132817). It is anticipated that the study's impact will increase with ongoing publication and dissemination of novel results.

The Risk of Infectious Diseases in Prison-Based Health Care Workers

Project Period:
2002 - 2005

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Johns Hopkins University
Martin Sherman, PhD
Loyola University

Co-Investigator(s):
n/a

Abstract:
The purpose of this research project was to determine the prevalence and risk factors for infectious diseases in correctional healthcare workers (CHCWs).

Impact:
The rate of blood/body fluid exposure in CHCWs was similar to published reports on hospital-based HCWs, even though the acuity of care provided is lower in the corrections setting than in hospitals. Despite the high rates of hepatitis B vaccination and immunity, the relatively high rate of PIs and low rate of reporting are a concern. With respect to the prevalence of tuberculin reactivity, although the rate in CHCWs was high, the risk factors were predominantly demographic, rather than occupational. The difficulty and challenge in conducting research studies that involve this population of HCWs has, to some degree, kept this HCW population "below the radar" so to speak. Nevertheless, these data suggest that CHCWs are a population of HCWs at risk of exposure to infectious disease pathogens. Interventions shown to be effective in reducing exposure and encouraging reporting in other HCW populations should be considered and evaluated in correctional health care settings, although a tailored approach may be required to address infection control barriers that are unique to the correctional setting.

• Intervention Effectiveness Research •

Evaluation of a Decking Fall Protection System

Project Period:
2001 - 2002

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Key Partner(s):
International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers

CAPCO Steel Inc.

Co-Investigator(s):
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Innovative Safety

Abstract:
Construction of steel frame buildings is very hazardous, with a high risk of falling. Installing metal decking over the beams to form a foundation for floors of the building is one of the most hazardous activities during structural steel erection, especially the risk of falls from the unprotected sides and front of the leading edge, through holes in decking, or due to buckling of the decking. The goal of this project was to evaluate a leading edge fall protection system used by Capco Steel Inc. since 1999. The evaluation involved the observation of the installation, training in use, and use of the fall protection system at six Capco Steel construction sites, and collection of fall data and man-hours of installing decking.

Impact:
First, reducing the high fatality rate among ironworkers in structural steel erection is of great concern to ironworkers, contractors, and owners of the structure under construction. Many contractors are adopting policies of 100% fall protection above 6 feet. This evaluation demonstrates that Capco Steel's Decking Fall Protection System is one proven way for contractors to achieve fall protection during decking operations. CPWR is presently developing a 20-minute videotape demonstrating how to install this fall protection system and how to use it. Second, OSHA's negotiated rule on structural steel erection, which became effective in 2002, allows specially trained workers installing metal decking inside a controlled decking zone with fall hazards of less than 30 feet or two stories to work without fall protection (29 CFR 1926.760(c)). This study shows that there is now an effective method of fall protection for workers installing steel decking, which invalidates this exemption from standard fall protection requirements.

The Impacts of OSHA Inspections on Manufacturing Injuries

Project Period:
2000 - 2002

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Co-Investigator(s):
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Abstract:
This project created a data set linking OSHA inspection records with plant lost workday injury records from the BLS Survey for manufacturing for 1992-1998. Using this data along with data from two earlier periods, we show that there has been a decline in the preventive effects of OSHA inspections in federal states from 1979-1985 (15% reduction in injuries) to 1987-1991 (8%) to 1992-1998 (1%). Declines were found for most sized groups and most inspection types. For all states, the 1992-1998 data showed that preventive effects were generally found only in non-union workplaces with under 100 workers. The reductions in injuries were as large for injury types unrelated to OSHA standards as for those related to standards, , indicating that the mechanism through which inspections work is not limited to the detection and correction of violations. Among standards violated, only the requirement for personal protective equipment showed a strong effect on injury prevention.

Impact:
The papers describing our results are being published this spring and summer, so it is too early to assess the impacts of the work. We believe that our work may have an impact on inspection priorities for OSHA.

California Agricultural Ergonomics

Project Period:
1998 - 2001

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Key Partner(s):
California OSHA, Education & Training

State Compensation Insurance Fund of California

AgSafe

University of California Cooperative Extension
University of California Center for Occupational & Environmental Health

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Julia Faucett, PH.D.
Occupational Health Nursing, UC San Francisco
Ira Janowitz, PT, CPE
Ergonomics Program, UC San Francisco

Abstract:
In 1997, California OSHA promulgated the nation's first standard regulating work-related repetitive motion injuries. Using accepted ergonomics methods and the standard's requirements, a set of educational materials was prepared for agricultural employers and used to train management-worker teams with five different agricultural operations. High risk tasks were identified for each cooperator using injury records, worker consultation, and ergonomics checksheets. Working with cooperator committees, specific preventive interventions were developed for targeted high risk tasks. More than 12 different types of ergonomics hazard controls were given field trial, involving over 250 workers. Both ergonomics and health outcomes were evaluated for each intervention. While the effectiveness of these controls varied considerably, the project did demonstrate to the industry that a best practices approach, based on the California OSHA standard, enabled satisfactory good faith response efforts at acceptable costs for most involved employers.

Impact:
The project's best practices agricultural ergonomics materials are available statewide in both English and Spanish. Based in part on the project's intervention trial results, both stooped postures and hand-cutting technologies have been identified as widespread risk factors for which satisfactory engineering controls are not commercially available. This directly led to a NIOSH-funded conference held in California in 2004 on research on stooped postures in the workplace. In a related effort, California's Division of Occupational Safety and Health implemented in 2004 new regulation on hand weeding in agriculture. The study also provided field pilot demonstrations that increasing work rest breaks for workers involved in such tasks as little as 20 minutes per day produced significant worker symptom reduction without unacceptable productivity reduction. This information was presented to the California Division of Labor Standards Enforcement in 2005 as it considered its proposed emergency regulations (subsequently withdrawn) revising meal-period requirements for California employees.

Effectiveness of a Machine Guarding Intervention

Project Period:
2002 - 2007

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Abstract:
Amputations, a serious form of work-related trauma, affect between 15,000 and 20,000 Americans each year. Minnesota Sentinel Event Notification System for Occupational Risk (MN SENSOR) data indicate that primary and fabricated metal industries have the fourth highest rate of work-related amputations. The objectives of this research are to: (1) Evaluate small- and medium- size machining and metal-stamping shops with regard to the availability, functionality, and use of machine-guarding; (2) Identify critical factors for implementing and conducting effective health and safety programs, including the identification and elimination of barriers to program success; and (3) Implement and assess the effectiveness of an intervention that uses a combination of control technology, regulatory guidelines, and worker/owner training in a randomized controlled trial.

Impact:
Investigators and the project advisory board have provided safety services to almost 40 facilities. This includes a comprehensive evaluation of their work environment as well as provision of a complete set of materials for individually auditing machine safety within shops. Audit materials provide owners of metal fabrication facilities the ability to monitor safety within their own shops and adhere to regulatory and other safety guidelines. To our knowledge, this is the first comprehensive set of tools available for auditing machine safety.

Electrical Arc Injury Parameters and Prevention

Project Period:
1999 - 2004

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Co-Investigator(s):
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Abstract:
The development of conceptual and three-dimensional computational models for electrical arc events and their use in severity rating blast conditions for triage and prevention is addressed in this project. Specifically, the correlation between numerical simulations of acoustic forces and experimental data is expected to result in improved safety standards for electrical work practices around energized equipment. Hazard management of electrical arcs' acoustic component has not routinely been incorporated into electrical safety training. This project is essential to address the lack of data and analysis around the interaction of acoustic forces and workers during electrical arc events so that prevention strategies can be implemented. In part, blast effects may explain why electrical injury patients without external signs of electrical contact may have nervous system or hearing impairment. Information to be developed in this project is expected to serve as the foundation for future clinical and workplace recommendations.

Impact:
Our research progress is influencing US medical, electrical engineering, and electrical safety management by encouraging multi-disciplinary, cross-functional, and inter organizational collaboration acknowledging the "multi-hazard nature" of an electrical arc accident. By linking the basic science appreciation of injury as a resultant of energy transfer to the body, to electrical inputs and outputs in an electrical accident, we are creating awareness of an electrical arc as an "electro thermal chemical" or ETC event; and advancing safety by returning programmatic focus to classical considerations of industrial hygiene principals of electrical energy dosimetry depending on the frequency spectrum of the energy, and depending on the dose magnitude and rate. There is heightened interest in the incorporation of surveillance protocols using rapid response sensors and fiber-optic signal transduction to revisit engineering assumptions predicated on data acquired with 20th Century technologies. This trend is promising for re-calibrating ideas of "acceptable" electrical arc exposures.

Wisconsin Dairy Traumatic Occupational Injury Intervention

Project Period:
2001 - 2005

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various national and regional dairy trade publications
various national and regional sponsors of dairy trade shows and expositions

Co-Investigator(s):
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University of Wisconsin

Abstract:
We are accomplishing three specific aims in this project: (1) Continue, for 3 additional years, a community-based, information-dissemination intervention among 21,000 Wisconsin dairy producers that will reduce traumatic injuries by persuading operation managers to adopt safer and more efficient work methods. The investigators will reduce hazards (and thereby injuries) by improving information flow to dairy operation managers to persuade them to adopt production methods that are both safer and more profitable. (2) Conduct annual, large-sample, mail questionnaire evaluations to determine whether (a) our materials are reaching the target audience and which intervention aspects are most effective, and (b) dairy producer adoption and awareness of each production method have increased. (3) Add one or two traumatic injury-reducing production methods to the intervention after seeking out reports from farmers and others about emerging production methods.

Impact:
This work was innovative because the intervention: (1) promoted engineering controls by substituting safer and more profitable practices, (2) intervened with a relatively large subject population of thousands of operations, (3) utilized the full range of existing information channels for farmers, and (4) evaluated the intervention at baseline and after each year over a multi-year time frame. In most industries, many managers continue to rely on "older" production practices despite the ready availability of more efficient, less costly and less hazardous practices. Often, what appears to stand in the way is a lack of awareness on the part of firm managers about the existence, value, and ease of use of the improved practices. This is at least in part attributable to the absence of convincing,

comprehensive, and well-targeted interventions to optimize information flow. Our research results provide evidence that better information flow is associated with increased adoption of safer production practices.

Surveillance Research Methods in Construction Injury

Project Period:
2002 - 2006

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
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University of Colorado

Hester Lipscomb
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Dennis Lezotte
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Abstract:
Construction workers have among the highest injury rates, yet significant challenges remain in understanding their work exposures and associated injuries, for reasons associated with the way they work. Construction workers are mobile and work for multiple contractors, making them difficult to enumerate. Their job sites constantly change as do associated hazards. The work is often done by multiple trade groups with different responsibilities, different immediate supervisors, different safety priorities and training requirements, and different compensation carriers. We are evaluating several injury surveillance methods, including gathering detailed information about occupational injuries, observing hazards, and collecting information directly from workers on a long-term commercial construction site with a diverse workforce. Data have been collected through a combination of quantitative and qualitative methods. The result should be an improved understanding of workers' injury experience as well as the context in which injuries occur on complex construction projects, information useful for guiding prevention efforts.

Impact:
This project is in the data analysis stage, and impact at this stage cannot be measured.

OSH Program Evaluation in Manufacturing and Small Business

Project Period:
1999 - 2006

Researcher Name:
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Key Partner(s):
Participating large and small manufacturing worksites in the "Wellworks-2" and "Cancer Prevention in Small Business" trials (New England area).

Co-Investigator(s):
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AM Stoddard
New England Research Institutes, Boston

R Youngstrom
Dana-Farber Cancer Institute, Boston

C Roelofs
Univ. of Massachusetts, Lowell

Abstract:
Programmatic or systematic approaches to occupational safety and health (OSH) have long been acknowledged as essential to the prevention and control of occupational injury and illness. In the last two decades, OSH programs or management systems have emerged internationally as a major strategy for addressing workplace safety and health. OSH program regulations and voluntary guidelines have been developed or are under development in numerous countries, including the US. In this project, we developed methods for assessing the scope and quality of OSH programs as well as related organizational-level exposure prevention efforts, and assessed the effectiveness of interventions to improve them. This project was built on two randomized controlled intervention trials: "WellWorks-2" (1996-2000), and "Cancer Prevention in Small Business" (1999-2003), substantially expanding the occupational health emphases and data collections beyond the primary health promotion emphasis in each of these parent trials.

Impact:
Findings strengthen the accumulating evidence of the need for management-focused intervention to improve OSH programs and exposure prevention in large manufacturing worksites. Findings also demonstrated that small manufacturing worksites can mount comprehensive OSH programs and upstream exposure prevention solutions. Thus, being small is not necessarily a barrier to these organizational-level OSH activities. Our Exposure Prevention studies have also confirmed prevalent views that a dearth of quantitative exposure monitoring exists in general industry. The Exposure Prevention rating

method offers a complement to traditional exposure monitoring and intervention needs assessment. Further, it translates ratings into upstream hazard control intervention advice for the user. We have been contacted by numerous companies and researchers asking for the newly developed measurements tools, which we have provided free-of-charge. We seem to have achieved, to some extent, the goal of developing new tools that are amenable to and attractive for use by both researchers and practicing professionals.

Evaluating Exposures Under OSHA's 1984 EtO Standard

Project Period:
1999 - 2006

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Co-Investigator(s):
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Abstract:
Long-term trends in ethylene oxide (EtO) worker exposures were assessed for the purposes of exposure surveillance, and evaluating the impacts of OSHA's 1984 and 1988 EtO standards. The specific aims of the study were: (1) to characterize EtO exposures in relation to OSHA regulatory pressure; (2) to identify potential determinants of EtO overexposures, and (3) to assess compliance with the EtO standard.

Impact:
The work of this project figured prominently in OSHA's Look Back review of the EtO Standard [OSHA, 2005]. The standard has been continued without change. This research was central to various findings of OSHA's review, including the continued need for the Standard, the lack of evidence of adverse impacts on "'small entities", and needed clarifications of worker training and alarm requirements. Key findings and implications for policy and practice were disseminated widely to hospital employee health professionals through two stories in the Hospital Employee Health Newsletter on the 2001 & 2004 Am J Public Health papers [Marill 2004 & 2005]. Insights gained through this research were also applied to the emergent problem of EtO explosions in commercial sterilization facilities. Dr. LaMontagne participated in the development of a widely disseminated NIOSH Hazard Alert [NIOSH, 2000] to address this problem. Various other resources for practitioners are detailed under "Products."

Risk Factors for Occupational Knee Injury and Disability in the U.S. Army

Project Period:
1999 - 2001

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Co-Investigator(s):
n/a

Abstract:
Using the Total Army Injury and Health Outcomes database, we completed case-control comparisons of occupational knee injury and knee-related disability in the U.S. Army. Separate comparisons were nested in the population of U.S. Army personnel, 1980-1997. Aims: (1) identify predictors of occupational knee-related disability; (2) demonstrate that related case-control comparisons can identify differences in determinants of causally related outcomes (injury and related disability); (3) demonstrate that administrative data offer a cost-effective resource. Results: we found non-white men and women had 30% lower risk than whites for injury and disability. Age was associated with both outcomes for women, and with disability for men. Other associations differed by gender and outcome. Conclusions: Gender-stratified logistic regression models showed independent contributions of sociodemographic and occupational characteristics to risk. Administrative data were effectively used for separate case-control comparisons that identified risk factors for related outcomes.

Impact:
Identifying occupational risk factors for knee-related hospitalization and disability among Army personnel may be helpful in reducing the risk of future knee injuries and disabilities. Such risk factors may be modifiable by implementing changes to work tasks, training, equipment or job assignments. Interactions between occupational and demographic characteristics suggested there may be subgroups within certain job assignments that are more susceptible to injury or disability than others. If so, then a targeted evaluation of the adequacy or appropriateness of equipment, training, or job assignments could increase the efficiency of future intervention efforts. These analyses also demonstrated the utility of administrative data for analytical research. The complexity of the analyses we were able to carry out, and the rich variety of results ob-

tained, show the cost-effectiveness of using existing data for analytical epidemiology. This approach should be considered a reasonable alternative to other, more expensive research paradigms.

Testing Theory-Based Alerts

Project Period:
1999 - 2004

Researcher Name:
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n/a

Co-Investigator(s):
Tara Williams
NIOSH

Abstract:
The goal of this project is to identify the characteristics of NIOSH Alerts that produce the strongest levels of receiver awareness, comprehension, acceptance, and use. Researchers have conducted a systematic, theory-based, long-term series of field experiments with skid-steer loader operators using the NIOSH Alert "Preventing Injuries and Deaths from Skid-Steer Loaders" DHHS (NIOSH) Pub No 98-117. The concepts of the Elaboration Likelihood Model and imagery have been applied to the case studies and recommendations found in the Alert. In order to test the effectiveness of the experimental manipulations, participants were asked to review the Alert and complete a survey assessing their attitudes, beliefs and intentions to following the safety recommendations.

Impact:
The knowledge gained from this project will be used to guide the design and execution of future studies and will be used in the creation of future NIOSH Alerts.

Evaluation of Traumatic Injuries in Healthcare Workers During Surgery

Project Period:
2001 - 2005

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Co-Investigator(s):
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Abstract:
There are over 8 million health care workers (HCWs) in the U.S. and approximately 600,000-1 million needle sticks occur resulting in 1000 new cases of HIV, HBV, HCV among HCWs. Recent increases in the rate of needlestick/sharp injuries and exposure to bloodborne pathogens has been reported to be greater than 50% in HCWs who work in the operating room (OR) as compared to other HCWs in other settings. Thirty-three percent of the injuries occur in the surgical field, 25% occurring at the surgical site, 59% occurring with the non-dominant hand. This study investigated: (1) the factors associated with needlestick/sharp injury during a surgical episode and (2) evaluated specific surgical factors that impacted on the rate of traumatic (needlestick/sharp) during surgery. Data were collected in two phases: (1) HCWs involved in the study using an indicator glove to detect sharp injuries and (2) HCWs using bunt needles engineered to reduce the rate of needlestick/sharp injuries.

Impact:
Although the use of an indicator glove system to detect needlestick injury would seem appropriate for clinical use, our data demonstrated that double gloving provides the same protection. This is an important finding since HCWs can adopt double gloving practices without having concern about additional protection. Second, the use of a blunt needle may be a more important finding. Aspects of the factors associated with the use of a blunt needle will provide better worker safety in the operating room. Although our data has not been analyzed, the impact of the use of blunt needles may change the basic operating room "standard of care" associated with the use of sharp needles for routine surgery.

Work-Site Intervention to Reduce Work-Related Assault Injury

Project Period:
1996 - 2001

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Los Angeles Police Department

Korean American Grocers Association
KAGRO "Project Build-Up"

Oxnard Police Department

Co-Investigator(s):
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University of North Carolina

Lawrence Chu, Ph.D.
Calif. State Univ., Northridge

Lisa Meneshian
University of California at Los Angeles

Abstract:
Homicides and assaults have increased in the workplace. The major objective of this study was to determine the effectiveness of a community-based, business-site educational intervention to reduce work-related assault injury in high-risk business populations. The intervention program was developed to meet the individual needs of each business. Other objectives included identifying risk factors for workplace assaults, describing the incidence of workplace assaults in selected communities, and identifying specific environmental changes or groups of changes that decrease workplace violence. Additionally, the project identified and examined emerging trends, and correlated the level of individual store compliance to the intervention program with workplace violence event rates. Several important collaborations established in the course of the study will assist in further dissemination of the program.

Impact:
The Workplace Violence Prevention Program provides important information that is not widely available to small business owners. Because this is one of the first federally-funded projects to develop and implement such a program, and since it does appear to be effective, we felt it was very important to make efforts to increase the availability of the program. Thus, we made several important collaborations that will assist with further dissemination of the program: Korean American Grocer's Association; Oxnard Police Department; Cal/OSHA Consultation Services; and the Los Angeles Police Department. All of these organizations have received some training and materials to assist them in continuing to provide the project's important prevention information.

Etiology of Injury in Drywall and Residential Carpentry

Project Period:
1998 - 2002

Researcher Name:
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Carpenters District Council of Greater St Louis

Carpenters Joint Apprenticeship Training Program

Homebuilders Association of Greater St. Louis

Co-Investigator(s):
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Dennis Patterson
Carpenters' District Council of Greater St. Louis

Wilfred Cameron
The Center to Protect Workers' Rights

Abstract:
Construction workers have high rates of work-related injuries. This research sought to determine if active injury investigations could identify causes of work-related injury among carpenters and specific risk factors for back disorders that result in prolonged loss of time from work. The investigators: (1) identified a cohort of drywall and residential carpenters to participate in a prospective study of the etiology of workplace injuries; (2) developed methods for reporting injuries, systematic collection of data from injury investigations, and analyses of both coded and descriptive data; (3) conducted both rate-based and case-based analyses of injuries among the defined cohort of drywall and residential carpenters; and (4) demonstrated the use of these prospectively collected data in exploring risk factors for prolonged loss of time from work following back injury using a case-control design.

Impact:
The Carpenters Joint Apprenticeship Program in St Louis, Missouri instituted a nail gun training program for early apprentice carpenters based on study findings. To our knowledge this is the only formal training program that addresses safe use of these tools. A new grant is evaluating the effectiveness of the program.

Workplace Violence Risk in Home Health Workplace

Project Period:
2002 - 2005

Researcher Name:
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Key Partner(s):
Baltimore County Public Health Nursing Division

Baltimore County Older Adult Services Division

Veterans Affairs Home-Based Primary Care

Visiting Nurses Association of Maryland

Co-Investigator(s):

Kate McPhaul, RN, PhD
University of Maryland, Baltimore

Karen Soeken, PhD
University of Maryland, Baltimore

Carles Muntaner
University of Maryland, Baltimore

Abstract:
Workplace violence is recognized as a significant occupational hazard in the healthcare sector, however little is known about the magnitude of the problem and effective prevention strategies in the home healthcare workplace. The overall objective of this exploratory research project was to collect pilot data to inform study design, sampling strategy, and measurement of workplace violence in the home health workplace. The pilot project developed measures for risk factors, threats and assaults, and current violence prevention strategies. This project also developed measures to assess current violence prevention strategies in home health and their coherence with OSHA's violence prevention guidance for home healthcare. The study used a mixed method cross-sectional design using focus groups, expert content reviewers, cognitive interviews, and a self-administered survey of visiting home health workers at four home health programs (n=130). This pilot project provided a conceptual and methodological blueprint for a large-scale investigation of workplace violence in home healthcare.

Impact:
The HVRS and EVPS demonstrated preliminary evidence for reliability and validity. These scales should be utilized in a representative sample of visiting home health providers. The findings also support conceptualizing home visit risk as a psychological job demand and employer violence prevention as a social support thus demonstrating that the Job Demand model holds theoretical promise for future workplace violence research.

Evaluation of Workplace Violence Prevention Intervention

Project Period:
2002 - 2007

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New York State Office of Child and Family Services and Safety Committee (OCFS)

Matt Kozack
Civil Service Employees Association (CSEA)

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Jonathan Rosen
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Co-Investigator(s):

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Jeff Johnson, PhD
University of Maryland, Baltimore

Karen Soeken, PhD
University of Maryland, Baltimore

Jeanne Geiger-Brown, RN, PhD
University of Maryland, Baltimore

Abstract:
Workplace violence is pervasive in the social service and health care settings. The program will be developed in concert with Federal OSHA guidelines for violence prevention. Management commitment and employee involvement are inherent in the design of the proposed study and include the formation and work of joint labor-management advisory groups. The aims of the proposed five-year project are as follows: (1) describe environmental, organizational, and behavioral/interpersonal risk factors for workplace violence present in the social service workplace, (2) assess the assault experience of staff in these workplaces, (3) examine the relationship between organizational factors and staff assaults in this sample of workplaces, (4) design and implement a violence prevention intervention within these workplaces, and (5) conduct a process and outcome evaluation of the intervention in sample workplaces one year following program implementation.

Impact:
Qualitative data collection is to be completed in Spring 2005. To date, the impact of the project consists of engaging management and front-line workers in the violence prevention worksite analysis.

Work-Related Assault: Impact of Training and Policy

Project Period:
2001 - 2003

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Co-Investigator(s):
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Patricia M. McGovern, PhD.
University of Minnesota
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University of Minnesota
Helen E. Hansen, PhD.
University of Minnesota

Abstract:
Work-related violence is a serious problem. While policies and training are recommended as part of a comprehensive approach to address occupational violence, little empirical literature exists to support this recommendation. The purposes of this study were to examine the relationship between (1) work-related violence prevention policies and (2) work-related violence prevention training, and the outcome of work-related assault against nurses. Data were collected as part of the Minnesota Nurses' Study, a two-phase population-based study of 6,300 nurses. A comprehensive causal model, using a directed acyclic graph, served as a basis for survey design, analyses, and interpretation. Sensitivity analyses were also incorporated regarding unmeasured confounders and exposure misclassification. Zero tolerance policies, and policies about types of prohibited violent behaviors may be protective in this population of Minnesota nurses, while the effects of violence prevention training appear to vary by topic. This study serves as a basis for future research.

Impact:
Certain types of violence-prevention policies, specifically zero tolerance policies and policies that address types of prohibited violent behaviors, appear protective in this population of Minnesota nurses. Regarding training, an increased risk of physical assault was identified for nurses trained in managing assaultive/violent patients at the univariate level; however, at the multivariate level, no statistically significant results remained. This lack of protection from training is consistent with previous research; however, the reasons for this lack of effect are unclear. In order to more thoroughly understand the impact of policies and training on occupational violence, additional research is necessary. Policies should be physically reviewed to better understand specific components included within each policy, and further details on training are needed, such as training content and methods. Work-related violence is a serious problem, and an urgent need exists to more fully determine the impact of violence prevention training and policies.

Auditory Motion and Pedestrian-Motor Vehicle Collisions

Project Period:
2002 - 2004

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Key Partner(s):
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The College of Wooster

Co-Investigator(s):
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Abstract:
The objectives of this research were to identify the specific acoustic conditions that maximize the perceptual bias to hear looming motor vehicles as closer than actual, thereby giving workers more time than expected to avoid collision. These results could then be used to enhance pedestrian safety through the use of temporary pavement treatments that take advantage of auditory perceptual biases. A series of experiments showed that (1) approaching vehicles that produce a modulated tone provide a greater margin of safety than either a constant tone or broadband noise, (2) as approach velocity increases, the margin of safety bias is greatly diminished, (3) at slower approach velocities, men are at significantly greater risk than women because women exhibit a greater anticipatory bias, and (4) the disparity in the anticipatory bias between men and women diminishes with increasing velocity, putting both sexes equally at risk for fast approaching vehicles.

Impact:
The current work has advanced our knowledge of auditory looming perception, a key skill necessary for avoiding approaching vehicles in the workplace. Specific recommendations include incorporating temporary pavement treatments in highway construction zones that create modulated tones when vehicles pass over them. These same strategies might also be employed in heavily traveled pedestrian crosswalks.

Evaluation of California Initiatives to Reduce Violence in Healthcare Settings

Project Period:
2002 - 2005

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Co-Investigator(s):
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California Department of Health Services
Carri Casteel
University of North Carolina
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Abstract:
In response to a growing awareness of violence against health care workers, the State of California implemented two initiatives, one regulatory and one legislative, to reduce violence in health care facilities. This quasi-experimental study evaluates the simultaneous effects of these two initiatives. The first objective is to conduct an impact evaluation to determine whether the initiatives led to improved security programs in California hospitals compared to control hospitals in New Jersey, which enacted no new initiatives. The second objective is to conduct an outcome evaluation to determine the effects of the two initiatives on decreasing violent event rates. Security programs are assessed through review of program material and multiple on-site interviews, and violent event rates are collected using the participating hospital's ongoing reporting systems. An interrupted time-series analysis will be used to determine whether the initiatives led to decreases in rates when compared with the comparison hospitals.

Impact:
Although no formal results are available, this project has already had impact among the participating hospitals. Following the murder of a psychiatric worker in California, the study team called together a symposium for the hospitals participating in the study. Every participating hospital sent at least one representative. The symposium, held at the California Department of Health Services, Division of Occupational Safety and Health, provided preliminary findings from the study and allowed participants to share success stories and strategies for security programs. In our final year of the study, we will conduct several more such symposiums.

Slip Trip and Fall in Construction and Transportation

Project Period:
1999 - 2002

Researcher Name:
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Colorado State University

Co-Investigator(s):
n/a

Abstract:
The focus of this effort was to develop a general understanding of the mechanisms of falls and slips on an unimproved surface. If these injuries can be controlled through engineering controls, future work will be directed toward testing of these controls. Information on the mechanisms of falls in this environment is currently limited. Possible engineering control approaches include specific work boot sole designs and modification of soil modulus and strength through the addition of fibers. The implementation costs would be modest and could have significant financial impact, particularly when viewed from the perspective of a human capital approach. A system was developed to predict the impact of some of the engineering controls on the mechanics of walking. A small-scale study of some soil additives was conducted. Variability of the response resulted in a need to consider alternative models for testing in the early stages of development.

Impact:
Given the preliminary character of this research the workplace was not impacted directly. Instead, the research began a process which is ongoing looking at the strain sensitivity of different soil surfaces. In particular, the strain sensitivity of soil surfaces from the horse racing industry have been investigated. This has allowed the work to continue with a higher load and more controlled surface properties. Extrapolation into the reduction of workplace injuries will allow further leveraging this continuing research.

Tailoring NIOSH Messages to Individual Health Construals

Project Period:
2000 - 2003

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Co-Investigator(s):
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NIOSH
Don Eggerth, PhD
NIOSH

Abstract:
The goal of this project was to assess the psychological characteristics of individuals regarding occupational stress. Specifically, registered nurses and licensed practical nurses in a healthcare facility provided self-report information on occupational attributional style, job satisfaction and attitudes, beliefs and construal ("wellness" construal and "illness" construal) regarding occupational stress. Also assessed were coping strategies, past participation in stress-reduction activities, and intentions to engage in steps to reduce or prevent stress in the future. Preliminary analyses found that occupational attributional style, job satisfaction, and stress were all associated with coping strategies. Specifically, nurses with a positive attributional style and a high level of job satisfaction cope with stress by focusing on positive ways to resolve the situation. These results and future analyses may be useful in the development of interventions for reducing workplace stress among this unique occupational group and in the creation of future NIOSH documents.

Impact:
Not applicable as the data analysis is not complete, and impacts cannot as yet be measured.

Postural Stability Effects In Low Seam Mining Tasks

Project Period:
1999 - 2003

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Key Partner(s):
United Mine Workers of America, (UMWA) District 17
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Co-Investigator(s):
Paul Succop, PhD
University of Cincinnati

Abstract:
The manual material handling tasks in underground low seam mines present a myriad of ergonomic risk factors, which place inordinate demands on miners' neuromuscular system. The overall purpose of the study was to quantify the postural instability of low seam miners while carrying out mine related tasks under exposure to the individual and combined risk factors of environmental lighting, surface condition and footwear used.

Impact:
The results allow enhancement of an existing model by adding the effects of new risk factors of restricted posture, glare, kneeling, task type and uneven/slippery surface, which are typically found in low-seam underground mines. In future field studies, this statistical model can be used to help evaluate the propensity for postural instability and/or loss of balance by measuring, in a walk-through evaluation, existing risk factors at the mining worksite and an appropriate intervention strategy can then be developed. Availability of such models may have a significant impact in identifying risk factors during job and workplace analysis of mining sites. Based on results from this study, improved work practices/training can now be developed to reduce the likelihood of workers' slips/falls while working in low seam mines. Results from this study can also be used to provide scientific data about postural instability under various combinations of workplace risk factors as input into the MSHA's human factors' training program software.

Designing Ergonomic Interventions for the Fire Service

Project Period:
2002 - 2005

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Key Partner(s):
Illinois Intergovernmental Risk Management Association (IRMA)

Northern Illinois Fire Chiefs' Municipal Alarm Box Aid System (MABAS) #3

Co-Investigator(s):
n/a

Abstract:
Musculoskeletal injuries consistently account for about half of all injuries to firefighter/paramedics engaged in emergency medical service (EMS) operations, as well as to EMS workers in the private sector. These injuries result in lost work time, permanent disability, and high workers compensation costs. The tasks performed during EMS runs that place these workers at risk for these serious sprain and strain type injuries include lifting and carrying patients for transport to the hospital. Unfortunately, few studies have addressed the biomechanical issues during emergency rescue operations. This research will develop and evaluate newly designed ergonomic interventions that reduce biomechanical loads and are considered worthy of adoption for use by the workers who perform

emergency medical/rescue (EMS) operations. This study is comprised of four phases: concept development using focus groups; equipment fabrication/method refinement; lab testing; and collection of usability and adoptability information from stakeholders. The investigators are using a participatory ergonomic process.

Impact:
Study is in progress, and impact cannot as yet be measured.

Reducing Violence Against Caregivers in Nursing Homes

Project Period:
1999 - 2003

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Co-Investigator(s):
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Marilyn Sommers PhD, RN, FAAN
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Abstract:
Nursing assistants (NAs) in nursing homes have the highest incidence of workplace assault in the U.S. The study objective was to test the effectiveness of a violence prevention intervention in increasing knowledge, self-efficacy and skills, and decreasing assaults. At pre-, post- and six months after the intervention, 138 subjects (3 intervention and 3 comparison homes) completed the Knowledge and Self-efficacy Survey, completed an Assault Log for 80 hours, and participated in a simulation to assess skills. Intervention subjects showed significant increases in knowledge, self-efficacy and skills. There was an interaction effect between the intervention and number of pre-intervention assaults. The intervention had a significant effect on those NAs who had less than 8 assaults pre-intervention ($p<0.001$) and no significant effect ($p>0.05$) on those who had more than 7 assaults on pre-intervention. Although the incidence of violence cannot be eliminated, it can be decreased and it should never be tolerated or accepted as "part of the job".

Impact:
Traditionally, abuse by residents against nursing home staff has been termed "aggressive or problem behavior" and was not considered violent, since many of the residents had dementia. Our research identified that many NAs do consider such incidents as "violent," suggesting that the emotional, physical and financial costs to employers, employees, and residents are significant. As a result of our work the American Journal of Nursing requested that we bring this problem to the forefront in the form of an editorial so that nurse leaders recognize the implications for healthcare worker outcomes. There were at least 2 nursing homes that have begun to require workers to report potential and actual violent incidents. We have received numerous requests for consultations across the country regarding violence in healthcare. Our research continues to have application to several healthcare settings. For example, we have conducted violence research in home healthcare and emergency departments.

Active Control of Workplace Noise Exposure

Project Period:
2001 - 2003

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Co-Investigator(s):
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Dep't of Mechanical Engineering, U. British Columbia

Abstract:
The ultimate objective of the research was to reduce occupational hearing loss and other detrimental effects of noise. It considered low-frequency noise, and involved investigating, demonstrating the utility of, and evaluating the feasibility and cost-effectiveness of active noise control (ANC) for controlling workplace noise exposure. The project was carried out in the following phases: workplace low-frequency-noise characterization;, computer modelling of sound fields in industrial workrooms, procedures for the optimal design of ANC systems, computer modelling of sample workrooms; experimental validation, investigation of the effects of obstacles on room sound fields, implementation and evaluation of ANC demonstration projects. The investigation concluded that it is feasible to apply active control technologies to attenuate noise in industrial rooms, if the control system is optimally designed.

Impact:
Noise is widespread in industry as is hearing loss, and is considered to be related to the A-weighted levels of noise exposure. Since the A-weighting strongly attenuates low-frequency noise, it is often not considered a significant cause of hearing loss. The research showed that low-frequency noise can represent a significant proportion of the noise exposure. Active noise control involves canceling noise by combining it with newly generated noise causing destructive interference. It is a new engineering technology that could revolutionize the field of noise control. Active noise control can be effective at low frequency. The research showed that it has the potential to be effective in industrial workrooms if the system is optimized for the particular application.

A New Training Intervention to Prevent Back Injuries

Project Period:
1998 - 2002

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
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Rush University

Abstract:
This project evaluated a new behaviorally-based approach to training lifting techniques. This approach incorporated biofeedback, quantitative performance measures, and individual coaching to shape lifting behaviors that reduce spinal load and low back disorder incidence. A one-year prospective randomized control trial was conducted in which 1,978 workers received either the LiftTrainerTM program or a video (control) training program. In the LiftTrainer program participants were instrumented so that the instantaneous dynamic spine moments at the base of the spine (L5/S1) could be computed and used to drive an audible feedback signal. A coach recommended behavioral adaptations to reduce the directional spine moments. Overall, there was no difference in the injury rates between training groups. However, when quantitative performance measures with the LiftTrainer group were taken into account, injury rates differed, thereby suggesting that the success of the LiftTrainer approach is dependent upon the level of lifting skill performance attained.

Impact:
This work has shown, despite recent research to the contrary, that there can be a measurable reduction in low back disorder by conducting training on lifting techniques. This work focused at the behavioral level which is consistent with other behavioral safety initiatives. Since the completion of the study, the training process has been adopted by a small number of distribution centers. More distribution centers are looking into incorporating this training program. We are currently attempting to adapt the training to those performing patient handling tasks as these workers continue to be in one of the highest risk occupations for back injury.

Effects of OSHA Guidelines on Violence Prevention in Mental Health

Project Period:
1999 - 2004

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Co-Investigator(s):
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University of Maryland, Baltimore
Karen Soeken, PhD
University of Maryland, Baltimore

Abstract:
Workplace violence is recognized as a significant occupational hazard in the healthcare and service sectors, in particular in the mental health setting. This participatory intervention effectiveness research was conducted (1) to document and describe a process to implement OSHA violence prevention guidelines; and (2) to compare assault rates, risk factors for assault, and job satisfaction one year before and after the OSHA guideline program. A violence prevention program, modeled after the OSHA guidelines, was implemented in three NYS in-patient mental health facilities between 2000 and 2004. A worksite analysis included review of data, focus groups, a pre-intervention survey, risk mapping, and walkthrough evaluation. Hazard prevention and control was accomplished by implementing recommendations from walkthrough surveys and focus groups. Evaluation of the program was accomplished through analysis of post-intervention survey and data one year following the implementation of the intervention.

Impact:
There is much evidence of the positive impact of the overall project on the study facilities. An evaluation of pre- and post-

survey data from the group of three intervention and three comparison facilities indicates a reduction of risk factors for assaults among all facilities, with a greater level of improvement in intervention facilities. A strong sense of staff empowerment resulting from the "solutions mapping" training and subsequent activities was reported by facility project advisory groups. The recommendations from the project are directed at sustaining the violence prevention efforts currently underway in the project study facilities and transferring the knowledge and experiences of the study facilities throughout OMH and beyond. Other successes include the hiring of a violence prevention coordinator at the agency level, a violence prevention training coach at the facility level, and the adoption of one facility's written program as the facility strategic plan.

Effectiveness of Farm Safety Day Camps for Children

Project Period:
2001 - 2004 (no-cost extension to 2005)

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Key Partner(s):
n/a

Co-Investigator(s):
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Progressive Agriculture Foundation

Abstract:
Farm safety day camps are offered in hundreds of communities to teach children safe methods of play and age-appropriate work on farms and ranches. Little research, however, has evaluated the effectiveness of these one-day, community-initiated events. This project evaluates the Progressive Farmer Farm Safety Day Camp Program®, a national program, sponsoring over 300 camps in more than 40 states and provinces each year. The program is designed to meet the needs of local communities by providing training, resources, support, and networking opportunities for conducting camps that provide age-appropriate, effective lessons in topics related to farm and home safety. The program is designed to be community-based, as each camp is planned and conducted at the local level, pairing the support and materials provided by the program with support from local individuals and organizations. This project involved both process and outcome evaluations. Outcomes assessed included knowledge and behaviors among children ages 8-13.

Impact:
Data regarding farm-related injuries have not been analyzed yet, so this measure of impact cannot be addressed. Survey data from the camp coordinators and camp volunteers indicate that local communities benefit from the day camps beyond the immediate education of the camp participants through enhanced safety awareness of the volunteers and other members of the community, and enhanced community strength and cohesiveness.

Leadership Intervention for Fire Service personnel

Project Period:
1998 - 2003

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Pat McGilligot
President of Local IAFF # 31

Kelly Fox
President of Washington State Council of Firefighters

Co-Investigator(s):
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University of Washington

Mary Salazar
University of Washington

Abstract:
This project entailed the development and implementation of an intervention to provide specific leadership, team building, and coping skills training for fire service officers. This worksite intervention improved the leadership effectiveness of the department's fire service officers as reflected in supervisory ratings given by their line firefighter and paramedic subordinates. Furthermore, improvements in leadership effectiveness resulted in a reduction in on-duty injuries, and absenteeism as well as decreases in adverse mental and emotional health outcomes. These health and safety benefits persisted for at least 18 months. This investigation included a cost-benefit analysis which documented the essential cost effectiveness of the proposed intervention. The findings from this research provide the basis for implementing this intervention with other fire departments and have direct relevance for parallel testing of the intervention for effectiveness with other high-stress occupations with elevated injury and/or illness rates (mining, constructions, and law enforcement).

Impact:
The impact of this field investigation (including the dissemination of our findings) is difficult to precisely gauge. While there does seem to be an increased appreciation of the importance of leadership in the fire service over the past decade,

the role of tradition, long-standing cultural norms and budgetary constraints in fire departments nationwide have presented formidable barriers to the wide-spread adoption and implementation of such a multi-component leadership intervention. Nevertheless, one important potential impact of our project's findings has been to help policy makers in the fire service (International Association of Fire Fighters (IAFC), International Association of Fire Chiefs (IFCA)) understand that controllable organizational factors in the fire service affect firefighter health and safety. This resonates with both fire administrators and fire unions and may set the stage for other similar and even other novel organizational job stress interventions.

Intervention to Mitigate Adverse Effects of Shift Work

Project Period:
1998 - 2002

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n/a

Co-Investigator(s):
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M Douglas Ris, PhD
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Abstract:
The hypothesis was that melatonin might facilitate adjustment to the sudden inversion of the activity/sleep cycle with the transition from day to night shift work, by synchronizing sleep to the desired schedule and improving alertness and mood. Subjects were physicians in training whose work requires intense alertness and vigilance. The design was a double blind, placebo-controlled, randomized, crossover treatment trial of melatonin during night work of 2 weeks duration for each treatment arm, and 2 baseline 2-week periods of daytime work. Outcome measures included: (1) sleep characteristics obtained by diary and wrist actigraphy, (2) alertness/vigilance assessed by the Conner's continuous performance test, and (3) mood assessed by the Profile of Mood States. This model can be generalized to other occupations that require a high level of vigilance and alertness. The expected benefits of the proposed intervention may lead to development of new strategies for adjustment to night work, resulting in increased safety and reduced accidents and fatalities related to sleep deprivation in night workers.

Impact:
This project had two impacts. First, in 2002, the Accreditation Council for Graduate Medical Education developed new standards for work duty hours for physicians in training. To meet these new requirements, many teaching hospitals considered greater use of brief night shift rotations similar to those described in this study, without taking into account the negative effects of night shift work. The present study increased awareness of leaders of teaching hospitals that doctors in training are susceptible to negative effects of shift work on sleep, mood, and alertness. Even when the night shift period is of short duration. The second impact, applicable to all workers assigned to intermittent or permanent night shift, is that although melatonin improves adaptation to experimental night shift work under strictly controlled environmental and life style conditions, it does not have beneficial effects on workers under naturalistic conditions.

Wisconsin Production Agriculture Intervention Evaluation

Project Period:
1999 - 2002

Researcher Name:
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Key Partner(s):
Cooperative Extension Service
University of Wisconsin

Various Wisconsin & regional fresh market vegetable producer organizations

Various national & regional fresh market vegetable producer trade publications

Various national and regional sponsors of grower trade shows and conferences

Co-Investigator(s):
Astrid C. Newenhouse, Ph.D.,
University of Wisconsin

Abstract:
This project accomplished three specific aims: (1) Continued, for an additional 24 months, an ongoing intervention among the 18% of the nation's estimated 30,000 fresh market vegetable operations in Wisconsin, Michigan, Minnesota, and Iowa as well as an intervention in Wisconsin among 19% of the nation's 116,874 dairy operations; (2) Evaluated the effectiveness of the interventions with annual mail questionnaires to separate, population-based probability samples from the study and control comparison groups to determine: (a) if our materials were reaching and being received well by the target audience, or (b) if farmer adoption or awareness of each innovation or perceptions of relative safety or profit advantages were changing; (3) Added new production methods to each intervention.

Impact:
First, our interventions attempted to translate research findings into standard practices for thousands of operations in regional sectors of the fresh market vegetable and dairy areas of the agricultural industry. Interventions seeking to accomplish goals of this magnitude are rare in the occupational safety and health research literature. Second, the interventions were innovative in the type of information dissemination they accomplished. We attempted to convey research findings to farm manager audiences using trade publications, public events, and other sources on which they were known to rely. Our study was also unusual for an injury intervention project, particularly in agriculture. Finally, coupling safety and profit in the production practices that we promoted was innovative. Farm managers are oriented toward improving their operation's productivity and reducing costs. Safety interventions in agriculture and other industries have seldom emphasized value to an operation's bottom line of economic viability along with the health and safety protections.

Health and Safety – Pollution Prevention in Hospitals

Project Period:
1998 - 2002

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Co-Investigator(s):
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Abstract:
An integrated pollution prevention (P2) and occupational safety and health (OSH) worksite intervention and alternatives assessment strategy was developed in hospitals. It was called the P2 OSH assessment. Methods included: (1) developing a participatory intervention model for introducing more environmentally-sound and safer materials and work practices for specific hospital procedures; (2) developing an integrated survey to evaluate environmental and occupational impacts of the intervention; and 3) conducting and evaluating interventions by applying the P2 OSH assessment pre- and post-intervention for eleven interventions in six hospitals. The emphasis on substitution (versus hazard control) and systematic assessment elucidated the benefits and limitations of each intervention and allowed for amelioration of potentially negative P2 and/or OSH impacts in the pilot phase, where they were easily addressed before full-scale implementation. Use of a systematic process like P2 OSH fostered both selection of more benign alternatives and design/re-design of products, materials and processes.

Impact:
As a result of this research, eleven interventions were performed: an aliphatic fixative replaced xylene in three histology laboratories; mercury reduction was implemented in three clinical laboratories; digital imaging replaced wet chemical film processing in three radiology departments; a less toxic aldehyde replaced formaldehyde in one histopathology laboratory; and microfiber mopping replaced conventional mopping in one hospital. Occupational and environmental health and safety impacts were observed and documented for all interventions. The alternatives generally were beneficial, although each had limitations resulting in process and task changes with potentially negative P2 and/or OSH impacts. When these were identified in the pilot phase they could be addressed before full-scale implementation. The P2 OSH method shifts the focus from hazard control to substitution. Because few ideal alternatives exist, the emphasis must be on a continuous process to identify, evaluate and implement alternatives, rather than on a particular alternative.

Evaluation of Farm Safety 4 Just Kids Safety Day Camps

Project Period:
2001 - 2005

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Key Partner(s):
Farm Safety 4 Just Kids Organization

Co-Investigator(s):
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Abstract:
This research evaluated whether farm safety day camps positively influence (1) children's knowledge about farm safety, their safety attitudes, and subsequent safety behaviors; and (2) parents' attitudes and behavior toward farm safety behavior. In addition, the effect of the camps on the local community was assessed. A multilevel, mixed-method evaluation strategy that combined quantitative and qualitative strategies was used to examine the long-term effects of the day camps on children, their families, and their communities. The study used a quasi-experimental, no-control-group, pre- and

post-test design with repeated measures that were collected over 18 months following the children's camp experience. This study was accomplished through collaboration with the North American Farm Safety 4 Just Kids (FS4JK) organization, local FS4JK Chapters, and the University of Kentucky. Results are being used to help FS4JK refine future programs and in assisting camp leaders articulate their theoretical framework, goals, and objectives for the day camps.

Impact:

Children made individual safety behavior changes based the new knowledge they learned at camp. Children seemed to be effective change agents for their homes as parents reported making safety changes after the camp.

Effects of an Ergonomic Intervention for Computer Work.

Project Period:
2000 - 2005

Researcher Name:
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Tom Driscoll
Kaiser Permanente, Oakland, CA

Co-Investigator(s):
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Robert Goldberg, MD
University of California, San Francisco

Abstract:

Customer service work at computers is associated with elevated rates of upper body musculoskeletal disorders. This randomized controlled intervention trial evaluated the effects of a wide forearm support surface and a trackball on upper body pain severity and incident musculoskeletal disorders among 182 customer service operators at a large HMO. If the participant's weekly pain severity or medication usage exceeded a priori criteria, an upper body physical examination was performed. Adjusted hazard rate ratios show a protective effect of the armboard for neck-shoulder disorders (HR = 0.49, 95% C.I. = 0.24 to 0.97). The armboard also significantly reduced neck-shoulder pain and right upper extremity pain in comparison to the control group. A return-on-investment model predicted a full return of armboard and installation costs within 2.4 months. Providing a large forearm support combined with ergonomic training is an effective and efficient intervention to prevent upper body musculoskeletal pain and disorders associated with computer work.

Impact:

This study finds that approximately one-half of the neck-shoulder disorders can be prevented by using a wide forearm support board while working on a computer. In addition, the use of a wide forearm support board significantly reduced the pain in the neck, shoulder and right upper arm and hand. Companies should strongly consider offering forearm boards to employees who do customer service work with a computer. Taking into account the cost of the forearm board and the installation cost and the reasonably estimated costs of preventing workers' compensation claims for neck disorders, a cost model predicted a return-on-investment of 2.4 months.

OSH Program Evaluation in Manufacturing and Small Business

Project Period:
2000 - 2002

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
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Dana-Farber Cancer Institute

Abstract:

In the last two decades, OSH programs or management systems have emerged internationally as a strategy for addressing workplace safety and health. We developed methods for assessing the scope and quality of OSH programs, and assessed the effectiveness of interventions to improve OSH programs, based on OSHA's 1995 Program Evaluation Profile. Results from field application of this assessment instrument in two intervention studies in manufacturing worksites indicate that it has reasonable discriminatory power. Most sites scored in the 60-80% range on a 100-point OSH program scale. In the intervention study conducted in large worksites, management-focused intervention led to consistently greater improvement in intervention versus control sites across all program measures, with significantly greater improvements in a measure of 'management commitment and employee participation. The intervention in small/medium sites was not associated with greater improvements in intervention versus control sites.

Impact:

With respect to implications for policy and practice, these findings suggest: (1) the observation of substantial room for improvement at most sites supports the need for intervention in the OSH program area; (2) The observed intervention-related improvement in 'management commitment and

employee participation' suggests likely benefits from intervention in this area; (3) Further empirical research is needed to improve and validate OSH program assessment methods and to evaluate the relative effectiveness of various intervention approaches.

Fall-Safe Partnership

Project Period:
1995 - 2005

Researcher Name:
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Key Partner(s):
Jim Platner
Center to Protect Workers' Rights

Tom Broderick
Construction Safety Council

Mark Monson
St. Paul Travelers Insurance Co.

Craig Behr
VeriTech Consulting Group

Co-Investigator(s):
Mark D. Fullen, MS, CSP
West Virginia University

Abstract:
The Fall-Safe program implements a construction contractor certification program. Fall-Safe is a management system that works to improve management use of existing fall prevention methods through use of training and an audit system to provide accountability. WVU serves as the certifying organization for contractors in West Virginia, and assists contractors in developing fall prevention programs, training of supervisors and workers, and quarterly audits 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 PDA that scores contractors on their fall prevention site programs and their compliance with OSHA standards related to construction falls.

Impact:
The results of the pilot study data suggest that the system has succeeded in reducing fall hazards for Fall-Safe contractors and should reduce fall injuries accordingly. Beyond the positive results of the pilot group, the audit tool developed for use in this program has been spun off as a "for profit" business funded by WVU and through the Small Business Innovation Research program. The company, BackPocket, Inc. is developing a commercial version of the audit tool that will be available for the construction and research community to use for safety audits and data collection. WVU Safety & Health Extension is currently working with The Center to Protect Workers' Rights in a subcontractor role on two projects that use a PDA-based audit tool for intervention research. The projects are to develop and implement an ergonomic best practices audit tool from block layers and to develop an electrical audit tool for use by an electrician. Other groups have contacted WVU for support and assistance in developing an audit tool for other intervention research project proposals.

Life Cycle Safety: An Intervention to Improve Construction Worker Safety and Health Through Design.

Project Period:
2001 - 2004

Researcher Name:
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Terry Wheeler
Industrial Design and Construction
Hoffman Construction Company

Co-Investigator(s):
Anthony Barsotti
Hoffman Construction Company

Billy Gibbons
DGI Ergonomics and Safety Leadership

Abstract:
This project documented and evaluated the development and implementation of a safety-in-design process during the programming and detailed design phases of a large capital construction project in the United States. This initiative brought together the owner, design firm, construction manager, and trade contractors in a mediated process in which these parties collaborated to assess and modify the design of a semi-conductor fabrication plant with the aim of reducing the risk to workers involved in the construction of the facility. Drawing on multiple data sources that included direct observation, document review, semi-structured interviews, and focus groups

with trade workers, the university-based research team identified factors contributing and limiting the success of this initiative and identified design changes that reduced risks to construction workers on this project that required approximately 3.3 million construction labor hours and involved more than 2,400 craft workers during periods of peak construction.

Impact:
This intervention to promote construction worker safety through a mediated design process was the first large-scale initiative of its kind in the United States. The design firm involved in this project is considering the promotion of safety-in-design to enhance its competitive position in the industry. The prominence of the owner and design firm involved in this initiative may prompt other owners to consider adopting a comparable effort, and design-build firms interested in developing a safety-in-design process have approached investigators on the research team about their work. As a result of the strong interest expressed in this project, the research team organized and hosted an international symposium on safety-in-design attended by over 100 researchers and practitioners. This symposium brought together leading experts in the field and led to the publication of an edited volume showcasing leading research and practitioner work in the area of safety-in-design.

Evaluation of a Decking Fall Protection System

Project Period:
2001 - 2002

Researcher Name:
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Key Partner(s):
International Association of Bridge, Structural, Ornamental and Reinforcing Iron Workers

CAPCO Steel Inc.

Co-Investigator(s):
Daniel Paine, CSE
Innovative Safety

Abstract:
Construction of steel frame buildings is very hazardous, with a high risk of falling. Installing metal decking over the beams to form a foundation for floors of the building is one of the most hazardous activities during structural steel erection, especially the risk of falls from the unprotected sides and front of the leading edge, through holes in decking, or due to buckling of the decking. The goal of this project was to evaluate a leading edge fall protection system used by Capco Steel Inc. since 1999. The evaluation involved the observation of the installation, training in use, and use of the fall protection system at six Capco Steel construction sites, and collection of fall data and man-hours of installing decking.

Impact:
First, reducing the high fatality rate among ironworkers in structural steel erection is of great concern to ironworkers, contractors, and owners of the structure under construction. Many contractors are adopting policies of 100% fall protection above 6 feet. This evaluation demonstrates that Capco Steel's Decking Fall Protection System is one proven way for contractors to achieve fall protection during decking operations. CPWR is presently developing a 20-minute videotape demonstrating how to install this fall protection system and how to use it. Second, OSHA's negotiated rule on structural steel erection, which became effective in 2002, allows specially trained workers installing metal decking inside a controlled decking zone with fall hazards of less than 30 feet or two stories to work without fall protection (29 CFR 1926.760(c)). This study shows that there is now an effective method of fall protection for workers installing steel decking, which invalidates this exemption from standard fall protection requirements.

Use of Action Research Methods for Targeted Intervention Evaluations in (TIE-IN) Construction

Project Period:
1999 - 2004

Researcher Name:
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Key Partner(s):
South Jersey Building and Construction Trades Council

Co-Investigator(s):
Vicki BorSherman, Dunn, Cohen, Leifer & Yellig

Abstract:
Construction is among the most hazardous industries in the U.S. However, it is organized in such a way that makes intervention research particularly challenging. Interventions which actively enlist the participation of those within the industry well positioned to influence change are more likely to have a lasting impact on improving safety and health conditions. We used participatory research methods to define an intervention focus and strategy with a local building trades council. They defined silica, asbestos and other dusts, and training of union representatives on how to address these hazards as our intervention focus and strategy, respectively. Hazard Information and Action Packets were developed and introduced as part of training workshops. Course evaluations

were generally very favorable. Pre- and post- intervention questionnaires completed by workshop participants showed statistically significant improvement at the 95% confidence level in questionnaire scores for both groups (pre-workshop and post-workshop) and individuals.

Impact:
Training instructors and union representatives from twelve different local union and training organizations were represented at the workshops convened on May 19, 2004 and on June 30, 2004. As part of this process, the South Jersey BCTC established a safety and health committee to guide our research. Participants in this intervention represent thousands of workers in southern New Jersey. Although it is difficult to measure the direct impact of our efforts, it is likely that participants utilized the information they gathered (through both print and verbal communication) to more effectively address silica and asbestos exposures routinely encountered in this geographic region. In addition, networks were established between CPWR, local unions, Hunter College and government agencies, which will facilitate future research endeavors aimed at improving occupational safety and health conditions in construction.

Improving Health on Boston CA/T Construction Project

Project Period:
1999 - 2004

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NE Laborers Training Center
Massachusetts Labor Management Construction Safety Alliance
Ironworkers Local 7
Operating Engineers Local 4 Training Center
Bechtel Parsons Brinkerhoff

Co-Investigator(s):
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University of Massachusetts, Lowell
Scott Fulmer
University of Massachusetts, Lowell
Abbas Virji
University of Massachusetts, Lowell

Abstract:
The objective of the UMass Lowell Construction Occupational Health Project (COHP) is the reduction of respiratory and musculoskeletal exposures in concrete work and other stages of construction through the introduction of appropriate interventions. The project evaluated the efficacy and effectiveness of engineering controls for the reduction of silica hazards in concrete finishing operations and for the reduction of musculoskeletal hazards in concrete pouring, from work and rebar tying. In addition, the project evaluated the effectiveness of technical and organizational interventions using a participatory action research design and developed training methods that support active participation of workers in the intervention process. COHP also produced a newsletter, On the Beam, factsheets, and a Web site to aid in information dissemination.

Impact:
Construction workers are exposed to many hazardous working conditions. The COHP project has focused its work on identifying and developing interventions to control respiratory and musculoskeletal hazards. From COHP hazard surveillance efforts several construction tasks were identified for the development of technical, engineering, and work organization controls. The effectiveness of these controls was shown to reduce the exposures of construction workers to silica and musculoskeletal disorders. Training and dissemination tools were developed to aid in making these findings known to the wider population and disseminated through local quarterly mailings to over 2000 construction workers and industry personnel

• Low-Back Disorders •

Intervertebral Disc Response to Cyclic Loading In Vivo

Project Period:
2002 - 2006

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n/a

Co-Investigator(s):
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National Institute of Arthritis and Musculoskeletal and Skin Diseases

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Columbia University
Mark Weidenbaum, MD
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Abstract:
Using an in vivo rat tail loading model, a well-defined loading regiment (static or temporally varying) can be applied to a specific vertebra and its adjacent discs via loading to surgical pins implanted in the neighboring vertebrae. With the ultimate goal of isolating the influence of joint-loading conditions on the response of the intervertebral disc (IVD), we set forth a number of specific hypotheses and specific aims to test our global hypothesis that there exists a range of loading magnitudes and frequencies that will safely maintain normal function and properties of the IVD. Outside of this range, non-physiologic compressive loading (overloading, high frequency, or static loading) of the IVD leads to disc degeneration as measured by decreased material properties (stiffness and modulus) and alterations to expression and levels of aggrecan, type I and II collagen, and cartilage oligomeric protein (COMP).

Impact:
This study provides fundamental insights to the role that biomechanical factors play in the etiology and progression of IVD degeneration. Information regarding the influence of loading magnitude and frequency on the biochemical and biomechanical properties of the IVD in our in vivo animal model may help in development of new strategies for prevention and amelioration of back pain and IVD degeneration for humans.

Reducing Low-Back Disorders Using a New Sitting Design

Project Period:
2002 - 2006

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Co-Investigator(s):
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Matthew Hepler, MD
Northwestern University

Abstract:
Work-related low-back pain (LBP) affects a large portion of the workforce and is thought to be related to sitting-induced sustained static muscle load and flattened curvature of the spine. This two-year project will investigate a new office chair design in which the back part of seat (BPS) can be tilted down with respect to the front part of the seat (FPS), providing adjustment of thigh and ischial support. The chair is also equipped with an enhanced back support adjustable in height and volume. It is hypothesized that sitting with lowered BPS and enhanced low-back support results in more evenly distributed contact pressure, reduced peak pressure under the ischia, increased lumbar lordosis, a forwardly rotated pelvis, and increased lumbar intervertebral heights. The investigators studied the biomechanical and neuromuscular effects of this new sitting concept and to evaluated quantitatively the benefits in LBP patients.

Impact:
Research findings of this study raised interests from LBP clinics. A small scale clinical trial is in planning with Dr. Joel Press, the Medical Director of the Spine & Sports Rehabilitation Center of the Rehabilitation Institute of Chicago. Since this is a 2-year project, the authors have concentrated on data collection and analysis. We expect to see more impact of our findings when further research and finding dissemination is carried out.

Spine Loading During Whole-Body Free-Dynamic Lifting

Project Period:
1997 - 2000

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Co-Investigator(s):
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Abstract:
A biodynamic model had previously been developed to account for the collective coactive influence of 10 trunk muscles upon the 3-dimensional loading of the spine. This study further developed the biodynamic model so it could accurately assess spine loading during whole-body free dynamic lifting activities, rather than a confined pelvic restraint system as was previously used. This research was accomplished via three

activities: (1) determining how the biodynamic model must be changed once the lower body is permitted to move during the lift, (2) developing instrumentation necessary to appropriately adjust the model for body posture changes that occur during whole body free dynamic lifting, and (3) validating the model. The resulting model facilitated the accurate assessment of biomechanical risk of low back disorders associated with broad exposures to manual materials handling activities.

Impact:
This study enhanced model fidelity so that the model was capable of: (1) accurately predicting spine load due to dynamic whole-body movements; and (2) uniquely defined the 3-dimensional spine loading characteristics experienced by an individual worker. The model has since been applied to the evaluation of dozens of risk assessment situations and has impacted the well-being of millions of materials handlers. Model improvements enabled the model to be used in a series of studies that were capable of defining risk associated with the workplace. For example, once these adjustments were made to the model, the model was used to evaluate: (1) patient handling risk, (2) lifting objects from different horizontal and vertical locations, (3) risk associated with lifting while experiencing back pain, and (4) the impact of psychosocial factors on spine loading. Collectively, these studies have helped us understand the nature of risk associated with occupational demands and have resulted in industry guidelines that impact millions of workers.

Neuro-Fuzzy Prediction of Spine Loads in Response to Risk Factors

Project Period:
2002 - 2006

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Abstract:
Electromyographic (EMG)-assisted models provide the only means to accurately assess and quantify the effect of changes in trunk muscle coactivation on spinal loading. However, the collection of EMG under most industrial conditions is impractical. The objective of this work was to develop a Spine Loading Assessment System (SLAS) that had the capacity to assess trunk muscle coactivation patterns and subsequent spine loading in response to multiple risk dimensions. This objective was achieved through the development of a hybrid neuro-fuzzy engine, which was based upon decades of EMG data collected within the Biodynamics Laboratory. This engine acts as a system artificial "brain," which is able to synthesize information about the workplace and assess how the trunk musculature would behave. This system permits one to accurately estimate spine loading as a result of physical workplace factors and individual factors, and can be used in the workplace without the use of EMG.

Impact:
This project greatly added to the body of knowledge regarding motor control in response to work-related variables. Currently most work assessment evaluations of low back pain risk are based upon assumptions on how muscles respond to work conditions. These assumptions have resulted in a lack of appreciation for the influence of muscle coactivation on spine loading. We were able to develop an EMG engine that was sensitive to the coactive nature of muscle recruitment during a task. This engine can be used to "feed" dynamic biomechanical models capable of accurately predicting spine loads during exposure to physical and psychological work influences.

Spine Loading and Muscle Overexertion During Repetitive Lifting

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2002 - 2005

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Abstract:
Although assessments have successfully evaluated occupationally related low-back disorder (LBD) risk during a single exertion, none have been able to effectively assess how risk changes during repetitive lifting at various lifting frequencies throughout a workday. It was hypothesized that both the lift frequency and the duration of the exposure to the lifting tasks would influence the trunk muscle recruitment patterns and the subsequent nature of the loads imposed upon the spine. In this study both experienced and inexperienced subjects lifted repeatedly during –six 8-hour test days. Subjects lifted at one of six lifting frequencies on each test day that varied from 2 to 12 lifts per minute. Spine loads were evaluated via an EMG-assisted biomechanical model throughout each lifting

day. The results indicated that exposure time was a more important indicator of spine load changes than lift frequency. Experience also played a role in reducing spine load.

Impact:
Our results suggested that lifting time exposure is an important factor in the design of work. In order to appreciate the full impact of materials handling risk, one must assess dynamic spine loads over at least a two-hour period. This may represent the upper limit of exposure time for workplace rotation schedules. In addition, these results suggest that moderate lift frequencies tend to minimize the loading on the spine because muscles are recruited with the least coactivation at these lift frequencies. Thus, this study provides some insight as the optimal lift rate for materials handlers. Finally, it appears that experienced subjects have an added benefit of lower spine loads that is manifested through a more orderly recruitment pattern among the trunk muscles which minimizes coactivation. Hence, these findings provide insight as to how subjects might be trained to minimize risk.

Biomechanical Psychosocial Risks for Low Back Disorders

Project Period:
2002 - 2006

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Abstract:
It is hypothesized that risk factors make independent contributions to the risk of low back disorders (LBDs) and that psychosocial work characteristics are more likely to increase risk for LBDs when biomechanical job demands are moderate to low rather than high. This study employs a prospective cohort design to quantitatively assess biomechanical exposure and psychosocial contributions to risk exposure in a spectrum of furniture distribution center environments. The ongoing data collection efforts associated with this project will permit us to accurately estimate the extent to which exposures (both psychosocial and biomechanical) need to be decreased to reduce LBD risk. This research will also be able to discern when and under what conditions an intervention to improve the psychosocial work environment will be likely to reduce the incidence of LBD and its associated morbidity among manual materials handling employees.

Impact:
Once this study is completed we will have the information needed to make evidence-based decisions about the efficacy of psychosocial-based interventions compared to biomechanically-based interventions. Given the exposure situation, we should be able to predict the benefit of independent risk interventions compared to intervention interactions. We expect that this knowledge will impact national trends in ergonomic intervention practices.

Ergonimic Evaluation of Vineyard Systems

Project Period:
2000 - 2004

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Rhonda Smith, MS
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Abstract:
Trellises in winegrape vineyards are used to create a plant canopy surface area. Trellis systems dictate the health effects, in terms of musculoskeletal disorders, on workers performing pruning and harvesting tasks. Currently, predicted health effects are not a factor in trellis system selection, in part because little is known about these effects, and labor costs are generally cheap. The main purpose of this project was to provide the

winegrape vineyard industry with specific recommendations about the long-term occupational ergonomics health risks for the most used trellis systems. The most used winegrape trellis systems were identified from existing records. We evaluated and rated these trellis systems for their ergonomics risk factors exposures relative to common tasks (e.g., hand harvest, pruning, and field MSD symptoms.

Impact:
This project resulted in new information pertinent to trellis system selection being described and made available to the industry. The Napa and Sonoma industry community, consisting of more than 250 wineries received regular updates from project staff at industry meetings and events. At this time a statewide Extension publication is planned summarizing the projects results and its implications for trellis selection by vineyard owners and managers. The major impact will be over time to make consideration of trellis system effect on worker health and occupational injury a factor in trellis selection. As thisoccurs, worker MSD injury rates should demonstrate observable decreases.

Low Back Pain in Cyclic and Prolonged Activities

Project Period:
2000 - 2003

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Abstract:
Millions of workers are employed in jobs requiring daily performance of cyclic and static flexion of the spine (e.g. loading, unloading, assembly lines, welding, bricklaying, roofing, and construction). Over years, these workers may develop a severe chronic spinal disorder called Cumulative Trauma Disorder (CTD), which results in large disability costs. The sources and the work exposure components that cause this disorder are unknown. The research conducted in this project identified that repeated flexion-extension of the spine (cyclic work) and prolonged static flexion result in stretch of the spinal tissues (e.g. ligaments, discs, capsule) over a day's work. Restoration of the resting (physiological) length of the tissues takes over 24 hours. Therefore, an overnight rest is not sufficient to restore normal conditions in the spinal tissues, and the work of the next day may add to the stretching such that over weeks or months, a permanent stretch and probably inflammation sets in the tissue as a chronic condition. An additional problem is an abnormal function of the spinal muscles when the tissues stretch, exposing the spine to instability and injury.

Impact:
Initial steps were made in outlining and understanding the mechanisms of development of cumulative low back disorders in workers who routinely perform cyclic and static flexion during their workday. The project has increased safety and health of workers in many segments of the economy by contributing to the implementation of preventive measures through eliminating continuous flexion of the lumbar spine providing sufficient rest, and rotating jobs during the day. Furthermore, with the understanding of the physiological processes responsible for the development and presence of CTD that was achieved through this project, a significant improvement in the treatment of the disorder could be implemented.

Musculoskeletal Disorders (MSD) in Nurses: Organization and Physical Work Factors

Project Period:
2000 - 2003

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Abstract:
Millions of workers are employed in jobs requiring daily performance of cyclic and static flexion of the spine (e.g. loading, unloading, assembly lines, welding, bricklaying, roofing, and construction). Over years, these workers may develop

a severe chronic spinal disorder called Cumulative Trauma Disorder (CTD), which results in large disability costs. The sources and the work exposure components that cause this disorder are unknown. The research conducted in this project identified that repeated flexion-extension of the spine (cyclic work) and prolonged static flexion result in stretch of the spinal tissues (e.g. ligaments, discs, capsule) over a day's work. Restoration of the resting (physiological) length of the tissues takes over 24 hours. Therefore, an overnight rest is not sufficient to restore normal conditions in the spinal tissues, and the work of the next day may add to the stretching such that over weeks or months, a permanent stretch and probably inflammation sets in the tissue as a chronic condition. An additional problem is an abnormal function of the spinal muscles when the tissues stretch, exposing the spine to instability and injury.

Impact:
Initial steps were made in outlining and understanding the mechanisms of development of cumulative low back disorders in workers who routinely perform cyclic and static flexion during their workday. The project has increased safety and health of workers in many segments of the economy by contributing to the implementation of preventive measures through eliminating continuous flexion of the lumbar spine providing sufficient rest, and rotating jobs during the day. Furthermore, with the understanding of the physiological processes responsible for the development and presence of CTD that was achieved through this project, a significant improvement in the treatment of the disorder could be implemented.

Psychosocial Risk Factors for Injury in Retail Material Handling Workers

Project Period:
1997 - 2000

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Abstract:
Back pain is a major source of lost work time. Occupational physical activity only accounts for a fraction of low back pain; therefore, a growing interest exists in investigating other possible causes of back pain including the psychosocial work environment. Material handlers (n=6,311) in 160 newly opened stores were inverviewed at study entry and approximately 6 months later. Factor analysis was used to reduce 37 psychosocial questionnaire items to seven distinct factors. After adjusting for history of back problems and work-related lifting, risk of back pain was moderately increased among employees who reported high job intensity demands (OR, 1.8), job dissatisfaction (OR=1.7) and high job scheduling demands (OR=1.6). Modification of the psychosocial work environment for material handlers in large retail stores may help reduce back pain among employees.

Impact:
This study investigates other possible causes of back pain that are not related to physical activity including lifestyle, and work-related psychosocial factors such as job satisfaction, job content, and relations with supervisors and peers. The study sample is four times larger than the study samples in the two largest previously published studies of associations between back pain and the psychosocial work environment. This large sample size provided sufficient statistical power to simultaneously examine associations between back pain and seven distinct work-related psychosocial factors, history of back problems, gender, and work-related lifting. These findings validate previous research that suggests modification of the psychosocial work environment for material handlers in large retail stores may help reduce back pain among employees.

• Mixed Exposures •

Diesel Exhaust and Occupational Lung Cancer Risk

Project Period:
1999 - 2001

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Co-Investigator(s):
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Alan Eschenroeder, PhD
Harvard School of Public Health

Abstract:
Previous studies have indicated that occupational groups exposed to diesel exhaust have an elevated risk of lung cancer. The purpose of this research was to assess lung cancer mortality in 54,973 US railroad workers between 1959 and 1980 and assess lung cancer risk associated with diesel exhaust exposure. An exposure index based on a review of historical records of railroad rosters and locomotive manufacturers' records was developed in order to estimate the impact of past exposures and estimate risk. Lung cancer risk was significantly elevated in these railroad workers, but it was not possible to relate lung cancer risk to a specific exposure level or duration. These analyses confirmed the earlier findings of an elevated lung cancer risk in this railroad worker cohort.

Impact:
Lung cancer risk was significantly elevated in railroad workers exposed to diesel exhaust between 1959 and 1980. These analyses confirmed the earlier findings of an elevated lung cancer risk in this railroad worker cohort. This railroad worker cohort was previously used to provide evidence for introduction of increasingly stringent regulations to limit diesel emissions from on-road and off-road emission sources. These additional results support the rationale for that effort.

Lung Cancer and Diesel Exhaust Exposure

Project Period:
1999 - 2003

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Harvard University

Abstract:
Diesel exhaust particles have mutagenic and carcinogenic compounds adsorbed on their surface. Evidence for carcinogenicity in humans has been based in part on studies in railroad workers published by our research group. The U.S. railroad industry changed to diesel power during the 1950's. We previously conducted a retrospective cohort study between 1959 and 1980 in 54,973 US railroad workers age 40 through 64 in 1959 with 10 to 20 years of service, with death ascertainment through 1980. In the current assessment, mortality and work history were updated through 1996, providing 38 years of follow-up. There were 43,593 total deaths including 4,351 lung cancer deaths. Adjusting for a healthy worker survivor effect and age, railroad workers in jobs associated with operating trains had a relative risk of lung cancer mortality of 1.40 (95%Confidence Interval=1.30-1.5. These results indicate diesel exhaust exposure contributed to lung cancer mortality in this cohort.

Impact:
In previous analyses in this cohort, lung cancer mortality risk was significantly elevated in railroad workers occupationally exposed to diesel exhaust between 1959 and 1980. In this analysis where mortality was assessed through 1996, lung cancer mortality was persistently elevated. These results indicate that the association between diesel exhaust exposure and lung cancer is real, and along with previous studies, support current efforts to reduce emissions in both occupational and general environmental settings.

Experimental and Computational Methods for Quantitating the Absorption of Complex Chemical Mixtures Through Skin

Project Period:
2001 - 2004

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Charles Smith, Ph.D.
North Carolina State University

Abstract:
In most environmental and occupational settings, chemical exposure is to complex chemical mixtures rather than individual chemicals. Estimating exposure for risk assessment under this scenario is difficult, as most research studies only assess single chemical exposure. Previous research has studied the nature of chemical interactions within a mixture that could modulate absorption across the skin. The present

research evaluated the interactions of 12 chemicals selected on the basis of physical chemical properties in three model systems of increasing biological complexity: inert silastic, in vitro skin diffusion cells, and ex vivo isolated perfused porcine skin flaps. Chemicals were dosed in all combinations of three solvents and two additives. Significant mixture effects on dermal absorption were detected that were related to the physical chemical nature of both the chemicals and mixture components. A single mixture factor was developed that corrected the normal individual dermal penetration equation for the mixture it was dosed in.

Impact:
The primary impact of this research has been to provide a tool that allows dermal absorption data collected under various experimental and occupational exposure scenarios to be extrapolated to a different study condition, independent of the vehicle or mixtures in which the reference chemical absorption parameters were determined. Until now, exposure conditions (vehicle, solvents, mixture additives) had to precisely match available experimental data and the occupational exposure of interest. This research provides a novel technique whereby these exposure variables can be quantitated into a mixture factor that compensates for the mixture effects on dermal absorption. This will greatly improve estimation of internal dose in occupational risk assessment. This approach has been bridged to jet fuel absorption studies supported by the Air Force Office of Scientific Research. Finally, this method would have direct applications to EPA and ATSDR in estimating dermal absorption of environmentally relevant compounds under different exposure scenarios.

Combined Effect of Radiation and Asbestos in Producing Pulmonary Fibrosis

Project Period:
1999 - 2003

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Abstract:
The aim of this study is to determine whether concomitant radiation exposure in asbestos workers increases the incidence of pulmonary fibrosis. 2263 asbestos -exposed former nuclear weapons workers from a medical surveillance program form the study cohort. PA chest radiographs and spirometry were performed for screening. 1157 workers had complete work histories, including external radiation badge doses and laboratory data. The demographic and fibrosis endpoints were similar in the entire cohort versus the 1157 analyzed. Asbestos exposure based upon years in a potentially exposed job was divided into low (< 13 years) and high (>13 years) dose groups. 31 (5.4%) of the high dose versus 24 (4.1%) of the low dose group had ILO scores > 1/0 indicating pulmonary fibrosis while 147 (25.7%) of the high dose group verses 121 (20.7%) of the low dose group met the case definition of pulmonary fibrosis (restrictive or mixed spirometry and/or parenchymal disease) ($p < 0.05$). In a 2 x 4 table analysis (binary fibrosis x binary asbestos and radiation exposure) 90 (32.3%) in the high asbestos/ high radiation (> 20mSv deep dose) group met the cases definition for fibrosis versus 81 (19.2%) in the low/low group ($p = 0.065$). A dose response was seen for fibrosis risk with increasing radiation at exposure rates around the occupational standard. Deep dose external radiation may add to the fibrotic effect of asbestos in workers exposed to both toxicants.

Impact:
The results could affect the current surveillance measures deployed for the hundreds of workers involved in the decontamination and destruction of 1940-60 era buildings around the nuclear weapons complex by lowering the threshold of surveillance for workers with both radiation and asbestos exposures. Additionally, the majority of the cohort is older than 60 years, with some receiving their significant exposures at older ages. This study assessed differential susceptibility based upon age to these two fibrinogenic agents and found a suggestion of increased effect at older ages. While it is unlikely that information from this study will impact primary prevention for these exposures, opportunities for secondary prevention through modifications of surveillance programs based on multiple exposures may possibly be influenced by these results.

• Musculoskeletal Disorders of the Upper Extremities •

Force-Repetition Interaction in a Rat Injury Model of Cumulative Trauma Disorder

Project Period:
2000 - 2005

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Abstract:
The long-term goals of this research are to use a rat model of cumulative trauma disorder (CTD) to examine the interaction between multiple risk factors that contribute to the development of CTD and to investigate interventions to prevent and reverse work-related musculoskeletal disorders (WMSDs). The main purpose of this project was to examine the short term effects (12 weeks) of different repetition rate-force level exposures on motor behavior and pathological outcomes in peripheral and central tissues using a novel posturally constrained voluntary motor task in a rat model. To this end, histochemical, molecular, physiological, and behavioral (functional) analyses were performed on forelimb muscles, tendons, bone and nerves as well as on spinal cord tissues after the performance of highly repetitive and/or forceful reaching and grasping tasks. Changes were monitored across weeks of task performance as well as with increasing repetition rate-force level exposure.

Impact:
In relation to the theories of WMSD development, our work and that of others lends credence to the over-exertion theory as an initiating and a propagating injury stimulus that leads to an inflammatory response (both local and systemic). We have speculated that the mechanisms leading to tissue repair are prevented by the continued cycle of tissue trauma in repetitive motion injury. While cumulative loading of viscoelastic tissues in the short-term may increase the likelihood that applied loads will result in tissue injury, it is nonetheless an over-exertion event that initiates an inflammatory response. Our findings support the theory that repeated bouts of injury, inflammation and fibrosis will eventually contribute to decreased tissue tolerance over time such that lower levels of exertion will lead to tissue damage, which will further decrease tissue tolerance and functional performance. Thus, a vicious cycle of injury leading to long-term functional disability is established.

In Vivo Rabbit Model of Finger Musculoskeletal Disorders

Project Period:
2003 - 2007

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Co-Investigator(s):
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Abstract:
The ongoing high costs and morbidity associated with occupational musculoskeletal disorders (MSDs) demands the investigation of risk factors for injury. Repetition of movement, forceful loading, and their combination (repetitive loading) are risk factors for MSDs. These are some of the risk factors for MSDs of the hand and other joints that can be modified at the workplace. This project proposes to use an in vivo animal model of repetitive finger joint loading to elucidate the relative risks of these factors (repetition and combined force and repetition) on the structural and molecular changes in joint tissues (specifically cartilage, bone and ligament). This project will (1) test the contribution of loading as a risk factor in repetitive loading (repetition alone vs. repetition with force; (2) measure the cellular response to repetitive loading by quantifying the change in gene expression and amount of specific proteins; (3) demonstrate location of cellular response to injury; and (4) identify any dose-response effects.

Impact:
The direct impact of this study on workplace safety and health is unknown at this time. However, there is an impact in advancing the fund of knowledge regarding one of the NORA focus research areas, upper extremity musculoskeletal disorders in the workplace. Ultimately, research using this tool (animal model for finger flexion) will help define safe work practices for repetitive hand tasks. For example, the results

of this project may lead to guidelines for effective preventative interventions of MSDs of the hand joints such as osteoarthritis.

A Model for Occupational Epicondylitis

Project Period:
1999 - 2002

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Abstract:
This was a Special Emphasis Research Career Award (SERCA). The goal was to develop a solid research program integrating biochemistry and mechanics that is able to answer key questions regarding work and musculoskeletal injury. This was achieved through both training in courses and with Ergonomics professionals, and in conducting a mentored research project. The research project plan was to develop a rabbit model of repetitive finger flexion to investigate occupational epicondylitis (tennis elbow). The Specific Aims were the following: (1) to develop and validate the model, (2) to identify relationships between the severity and location of the biochemical and histological outcome measures, and (3) to determine exposure-response relationships of force and repetition on the biologically important histologic and biochemical outcome measures.

Impact:
The direct impact of this study on workplace safety and health is unknown at this time. However, there was impact in advancing the fund of knowledge regarding one of the NORA focus research areas, upper extremity musculoskeletal disorders in the workplace. Ultimately, research using this tool (animal model for finger flexion) will help define safe work practices for repetitive hand tasks.

Effects of Repetitive Work on Fatigue of Long Duration

Project Period:
2001 - 2005

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Co-Investigator(s):
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Abstract:
Musculoskeletal disorders of the upper extremity associated with repetitive work may be caused by cumulative exposure. We hypothesized that muscle fatigue of long duration can serve as a measure of cumulative work exposure. In order to link aspects of exposure to repetitive work with changes in muscle physiology, we conducted a series of laboratory-based experiments that simulated repetitive wrist flexion work tasks. These experiments determined a relationship between repetitive work and muscle fatigue. The first set of experiments showed that fatigue can persist for more than 24 hours into the next workday, but does not accumulate over consecutive workdays. The second set of experiments showed that cumulative mechanical work, rather than cumulative activation or force, dominated the physiological response. The third set of experiments is determining the effects of several job task interventions.

Impact:
The overall aim of our research, which is to provide a measure of exposure to repetitive work, will be achieved in the short term: we can measure level of exposure during a single workday, but not over the course of a working week. The results of our experiments on the physiology of fatigue will impact the design of work tasks with better pacing of work and distribution of rest periods. We have also discovered ways in which people vary in their susceptibility to fatigue. These findings will drive basic investigations into muscle fatigue, but their impact in the workplace cannot yet be determined. Perhaps the most important single impact of our studies on worker health is a fortuitous result: in the course of validating a classical experiment that established acceptable workloads for repetitive work, we found an error that may make the existing standard too high.

California Agricultural Ergonomics Intervention Project

Project Period:
1994 - 1998

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State Compensation Insurance Fund of California
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Co-Investigator(s):
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Abstract:
This project's goal was to develop and assess the preventive efficacy of applications of previously validated ergonomics approaches to agricultural work. Plant nurseries constitute one of California's largest agricultural commodities. Review of reported injuries in three large nurseries suggested an MSD prevalence rate of 40 per 1000 workers per year. High risk tasks were described using injury records, worker consultation, and ergonomics checksheets. The most successful of several intervention concepts was a handle for picking up and moving the plastic plant containers. This tool significantly relieved stooped posture involved in spacing and trailer loading and unloading, and relieved pronounced finger pinch grip in lifting and holding containers. Workers reported statistically significant reduction in MSD symptoms when using the handles. Worker productivity with the handle tools was slightly better or the same for selected tasks.

Impact:
The project's results demonstrated that ergonomics methods have practical utility when applied in agricultural workplaces, and that these methods are acceptable to agricultural employers when introduced in a cooperative manner. This was an important industry demonstration during a time when California was considering a workplace ergonomics rule (later adopted). California OSHA education and training subsequently organized a special plant nursery workgroup to help disseminate information about the use of ergonomics approaches to injury prevention. The project's resulting data on the prevalence of MSDs in this industry focused new priority on ergonomics problems in the agricultural industries and led to the formation of the University of California Agricultural Ergonomics Research Center, which now has a program of continuing research. The project also led to a continuing series of industry-funded ergonomics research projects with plant nurseries. Finally, commercial production of an innovation directly from a research trial was an unusual and valuable impact.

Musculoskeletal Disorder Follow-up in Automobile Manufacturing

Project Period:
1998 - 2004
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Abstract:
Musculoskeletal disorders (MSDs) are a major source of morbidity and disability in many societies. Data are sparse on the "natural history" of upper extremity (UE) MSDs, including non-specific disorders, in populations with defined levels of exposure to ergonomic stressors. We conducted a follow-up study of automotive manufacturing workers six years after a baseline survey. All employed cohort members were sought for interview, screening physical examination, and observation of job duties; retired workers were contacted by mail and telephone for interview. The key areas of investigation were to: determine changes in ergonomic exposures in the study jobs, especially with regard to work organization characteristics; estimate prevalence, cumulative incidence and persistence of UE MSDs as a function of ergonomic exposures; examine work and health factors related to leaving employment; examine the validity of psychophysical ratings of ergonomic exposures; and evaluate the sensitivity of pressure pain threshold muscle testing as a screening instrument.

Impact:
This study originated under a joint company-union collective bargaining agreement that also initiated an ergonomics training program in all of the company's manufacturing plants and activated joint health and safety committees responsible for ergonomic hazard surveillance and job modifications. Results of this research (both the original study funded above and the follow-up study funded by NIOSH) have been reported to the union membership and to the union and company occupational health and safety technical professionals. Research findings have been incorporated into the ongoing activities in the study plants. Specific feedback and recommendations have included a list of study jobs, in descending order by ergonomic exposure level, as well as an instrument for assessment of the job ergonomic features by any employee who reports a MSD to the plant health department. Data from this research were submitted to OSHA in support of the

ergonomics protection standard that was promulgated and was briefly in effect in 2000.

A Model for Wrist and Elbow Musculoskeletal Disorders

Project Period:
2001 - 2006

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Key Partner(s):
n/a

Co-Investigator(s):
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Abstract:
A new animal model involving repetitive loading of the rabbit digit is used to investigate the role of various biomechanical factors in causing entrapment neuropathy of the median nerve at the wrist and tendonitis at the epicondyle. In addition, the study will identify early cellular and biochemical changes in matrix proteins and cytokines. This study has the potential to identify the characteristics of biomechanical loading which cause injury. The study may identify the biochemical pathways and time-frames of disease progression. The findings may lead to new strategies for treating and preventing entrapment neuropathies and tendon disorders related to work.

Impact:
This is the first study to demonstrate structural defects, specifically microtears, in the tendon due to repetitive loading. The study is not yet completed, but answers to the questions posed above could assist industrial engineers, ergonomists, and other health professionals in the design of safe work without unduly interfering with productivity. Most of the biomechanical factors investigated can be altered in the design of work. For example, if high loading rate is the major biomechanical risk factor, tasks and tools could be designed to minimize impact loading, peak accelerations, or sudden torque changes without limiting productivity. If repetition is the major risk, tasks and tools could be designed to eliminate extra repetitions, but maintain similar mean force patterns.

Tendon Force During Occupational Hand Activities

Project Period:
1998 - 2005

Researcher Name:
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University of California, San Francisco

Abstract:
The overall goal of this study was to determine the dose-response relationships of fingertip load to tendon load in order to provide guidelines for hand tool design and tool use to minimize tendon loading, and thereby reduce the risk of developing tendon-related disorders. The specific goals of this study were to: (1) investigate the effects of finger and wrist posture, external force distribution, and fingertip force rate on in vivo forces in the flexor digitorum profundus (FDP) and the flexor digitorum superficialis (FDS) tendons of the index finger; and (2) to evaluate the ability of a biomechanical model to predict these tendon forces. This information can identify finger positions and motions that are associated with lower tendon forces and may be used to design tools and tasks to decrease risk of tendon overuse injury and improve rehabilitation strategies.

Impact:
Tendon forces in the hand can be reduced with improved tool and workstation design. In order to reduce FDP tendon force, the tool design should promote a larger MP flexion angle, smaller DIP flexion angle, and a more perpendicular external force application. These adjustments in finger and external force orientation may be achieved by changing the shape of hand tools. The findings of this study suggest that limiting active composite finger flexion to MP angles of 45° or less may be a method of avoiding high tendon forces. These findings can assist the designers of hand tools, tasks and workstations in order to reduce the risk of developing musculoskeletal disorders, such as tendonitis, of the hands.

Ergonomic Interventions for Garment Work

Project Period:
2002 - 2005

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Co-Investigator(s):
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Abstract:
Since 1994, in the U.S., sewing machine operator has been listed among the 20 occupations out of 821 with the largest number of repetitive motion injuries and carpal tunnel syndrome illnesses involving lost workdays. We conducted a randomized trial of a newly developed ergonomic intervention package applied to sewing machine operators working in Los Angeles garment shops. These interventions were previously tested for acceptance by workers in Northern California and were modified to be applicable to Los Angeles garment shops. The proposed ergonomic intervention package included a highly adjustable ergonomic chair, a side table to support fabric pieces, a footrest for the left foot, and, on a need basis, improvements in lighting and vision correction. This project examined whether these interventions implemented at sewing workstations reduced rates of musculoskeletal disorders, severity of pain and impairment, and lost work time, compared with "placebo" (control) interventions.

Impact:
For the past two years, we have built strong partnerships with the garment community in California, including trade associations, manufacturers, community-based organizations, and garment workers. Due to the contacts we have made, a number of shops volunteered to participate in our project. Our study has also attracted a lot of media attention. We have been interviewed as part of KQED's California Report, Los Angeles Times, and Sacramento Bee, and other news media and have been portrayed as a project successful in helping and doing outreach to immigrant workers and employers in an industry that traditionally has been hard to reach concerning issues of occupational health and safety.

Cumulative Trauma Disorder: Skeletal Muscle Function

Project Period:
1995 - 2004

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n/a

Co-Investigator(s):
n/a

Abstract:
Chronic pain originating from the musculoskeletal system is a dominant cause of sick-leave in modern industry and often a very disabling and troublesome condition for the individual. Although the cause of this problem in skeletal muscle is unknown, one of the most frequent situations in which muscle pain is experienced is in industrial workers who have to move repeatedly and/or forcibly. Since variations in human exposure and response, together with the necessity for repeated tissue sampling, make man unsuitable as a research subject, we have developed a rat model of repeated strain injury. Using our rat model, the present study was designed: (1) to determine the dynamic factors (force, velocity, acceleration and dose) which produce dysfunctional versus adaptive muscles, (2) to unravel the factors and mechanisms that result in pathologic muscles, and (3) to study the functional outcome and reversibility of repeated injury.

Impact:
These studies illustrate that the mechanisms for muscle weakness and histopathologic changes (inflammation) following repeated muscle strains can be largely dissociated from each other. The underlying mechanisms for this dissociation (mechanical damage or calcium influx) help explain why there is no correlation between isometric force deficits and the number of pathologic cells. It also provides a rationale for the observation that the number of pathologic cells continually increases with stretch number, but the loss of isometric force appears to reach a fatigue limit. Finally, functional testing in humans exposed to repeated muscle strains and probably other types of muscle injuries will not allow the assessment of the degree of muscle pathology.

A Multidisciplinary Study of Mechanisms for Tendinitis

Project Period:
2002 - 2004

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Co-Investigator(s):
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Abstract:
Repetitive motion disorders affect millions of people in workplaces in the United States. Despite the increasing prevalence of the repetitive motion disorders, such as tendinitis, and the fact that repetitive motion disorders have become an extremely costly public health problem, important gaps exist in our knowledge about the pathophysiological mechanisms for these disorders. The goal of this project was to elucidate the cellular and molecular mechanisms for the development of tendinitis using a novel in vitro model and an animal model. We developed a novel in vitro model to investigate the expression of PLA2, COX, and their products (e.g., PGE2 and LTB4) in tendon fibroblasts in response to repetitive mechanical loading conditions; and an animal model to investigate the effect of PGE2 on the tendon's biological, biochemical, and biomechanical properties.

Impact:
Our work indicates that PGE2 and LTB4, produced by tendon fibroblasts in response to repetitive mechanical loading in vivo, may be an important factor that contributes to the development of repetitive motion-induced tendinitis, and that the routine use of COX inhibitors (NSAIDs) for the symptomatic relief of inflammatory tendon conditions may inadvertently worsen the processes responsible for the development of tendinitis. Based on these findings, it is suggested that NSAIDS should not be used for a prolonged time, and that the use of a dual inhibitor that can decrease both PGE2 and LTB4 levels for tendinitis treatment may be desirable.

• Organization of Work •

Effects of Extended Work Hours on Intern Health and Safety

Project Period:
2001 - 2005

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Abstract:
Knowledge of the physiological effects of extended work shifts (> 24 hours) in postgraduate medical training is limited. We conducted a prospective, nationwide Web-based survey in which 2,737 residents in their first postgraduate year (interns) completed 17,003 monthly reports that provided detailed information about work hours, extended work shifts, documented motor vehicle crashes, near-miss crashes, and incidents involving involuntary sleeping. Additionally, we conducted a prospective randomized study of twenty interns during two 3-week rotations in intensive care units (ICUs), during both a traditional schedule with extended work shifts every other shift ("every third night" call schedule) and during an intervention schedule that eliminated extended work shifts and reduced the number of weekly work hours. Seventeen of 20 interns worked more than 80 hours/week during the traditional schedule (mean, 84.9; range, 74.2- 92.1). All interns worked less than 80 hours/week during the intervention schedule (mean, 65.4; range, 57.6- 76.3).

Impact:
Extended-duration work shifts, currently sanctioned by the ACGME, pose safety hazards for interns. These results have important implications for medical residency programs, which routinely schedule physicians to work more than 24 consecutive hours. Eliminating interns' extended work shifts in an ICU significantly increased intern sleep, decreased attentional failures during night work hours, and reduced serious medical errors. Moreover, our data indicate that scheduling physicians to work such extended shifts poses a serious and preventable safety hazard for them and other motorists. Further modifications of ACGME standards, particularly with respect to shift duration, are clearly indicated to improve the safety of interns. Our findings in interns will likely have broader implications for all medical residents and others working long work weeks and shifts of extended duration. This research should be expanded to identify if these safety risks exist in the later years of medical residency and throughout medical practice.

Practical Circadian Interventions for Night Shift Work

Project Period:
1999 - 2002

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Co-Investigator(s):
Louis Fogg, Ph.D.
Rush University

Abstract:
Most night shift workers fail to adapt to their night work, day sleep schedule because their internal body clocks, which control their circadian rhythms do not phase shift (reset) to match the new schedule. We tested various combinations of interventions designed to reset rhythms and thus produce adaptation to night shift work. The interventions were: (1) a very dark bedroom and a fixed seven-hour dark time for sleep at home after each night shift, (2) wearing normal or very dark sunglasses on the way home after night work, (3) taking melatonin at bedtime before daytime sleep, and (4) intermittent bright light during the night shift. These interventions are feasible for real shift workers. The outcome measures were: (1) circadian phase, (2) daytime sleep duration, and (3) night work sleepiness and performance. The ultimate goal was to advise shift workers and their employers about the relative benefits of the various interventions.

Impact:
Although we were often interviewed by the media, it is difficult to assess how many real night shift workers have adopted these recommendations. Furthermore, the individual worker cannot implement all these interventions on their own. The employer must provide the right work schedule (permanent nights, or very slowly rotating schedules, in both cases with no overtime into daytime hours after night shifts), and has to allow the worker to work at least intermittently near a bright light box or source. We are currently conducting another simulated night shift study in which days off are interspersed between sets of night shifts. We will determine whether a compromise phase position, good for both night shifts and days off, can be produced and maintained with intermittent bright light during the night shift, normal sunglasses for the commute home and dark bedrooms for sleeping. This is a continuation of the original 3-year grant.

Impact Total Workload—Maternal Postpartum Health/Quality of Life

Project Period:
1999 - 2003

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University of Minnesota

Sally Kenney, Ph.D.
University of Minnesota

Ulf Lundberg, Ph.D.
Stockholm University

Abstract:
Mothers of infants have been one of the fastest growing segments of the U.S. labor force over the past 20 years. While it is well established that women face physical and psychological changes in association with childbirth, scant evidence documents the effects of employment policies and work

organization characteristics on women's health upon return to work. This study evaluated changes in women's health status after childbirth in relation to personal and employment characteristics (e.g., workload, use of family and medical leave, job stress) at childbirth, 6 weeks, 12 weeks, 6 months, 12 months and 18 months postpartum. Survey data were collected from medical records, in-person and by telephone. Multivariate analyses of survey data will identify workplace and job characteristics and personal choices that support women's well-being. This knowledge will facilitate the design of policy and program interventions relevant to employers, policy makers, and occupational health providers.

Impact:
Women who delivered by cesarean (C)-section (versus vaginally) had significantly lower general physical health scores at six weeks postpartum. The findings are important given recent estimates of a record high for C-section deliveries at 26% of all U.S. births in 2002. Even in the absence of surgical complications, women with c-sections were not completely recovered after six weeks, the typical time allotted for recovery from major surgery. This is likely because they were recovering from childbirth and surgery and had significant round-the clock responsibilities for dependent infants. The findings stress the importance of primary care and occupational health providers educating women about expected symptoms, disability duration, and appropriate length of leave from work by delivery type. Some mothers may adapt better upon return to work with an intermittent (rather than straight-time) family and medical leave, which is only an option if medically certified as necessary for a "serious health condition."

Work Organizational Factors and Psychological Distress

Project Period:
2002 - 2005

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Mathematheca Policy Research, Inc.

Human Synergistics International

Co-Investigator(s):
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University of Medicine & Dentistry of New Jersey

Robson, Mark, Ph.D
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Ohman, Pamela, Ph.D
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Abstract:
The goal of this exploratory project was to develop a methodology that can be used to examine the relationship between organizational factors, workplace disaster-related crisis intervention programs, and psychological distress as well as work productivity among employees exposed to a large-scale disaster in the work environment. Working with four major labor organizations in Manhattan, we recruited 380 office workers from fifteen worksites that were located within a ten-mile radius of the WTC to complete a survey. The specific aims of this survey were to (1) identify the resources that were available to workers in the aftermath of the disaster, (2) assess how helpful these resources were to the workers (3) determine the prevalence of current physical symptoms and psychological distress and their impact on work productivity, and (4) to explore the relationship between work organizational factors such as job-stress, workplace culture, disaster-related corporate programs, and workers' psychological well-being.

Impact:
This study provides useful data on the programs that were offered, as well as the individual (demographics) and organizational factors (size, culture, job stress) which predict utilization of those programs. This data provides useful information and insight for program planners in the event of workplace (and/or community) disaster events and is applicable to other types of corporate-sponsored health promotion programs.

Extended Work Schedules and Workplace Injury in Nurses

Project Period:
2002 - 2005

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Key Partner(s):
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Co-Investigator(s):
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University of Maryland

Abstract:
The goal of this exploratory project was to develop a methodology that can be used to examine the relationship between organizational factors, workplace disaster-related crisis intervention programs, and psychological distress as well as work productivity among employees exposed to a large-scale disaster in the work environment. Working with four major labor organizations in Manhattan, we recruited 380 office workers from fifteen worksites that were located within a ten-mile radius of the WTC to complete a survey. The specific aims of

this survey were to (1) identify the resources that were available to workers in the aftermath of the disaster, (2) assess how helpful these resources were to the workers (3) determine the prevalence of current physical symptoms and psychological distress and their impact on work productivity, and (4) to explore the relationship between work organizational factors such as job-stress, workplace culture, disaster-related corporate programs, and workers' psychological well-being.

Impact:
This study provides useful data on the programs that were offered, as well as the individual (demographics) and organizational factors (size, culture, job stress) which predict utilization of those programs. These data provides useful information and insight for program planners in the event of workplace (and/or community) disaster events and is applicable to other types of corporate-sponsored health promotion programs.

Management Practices as a Factor in Workplace Violence

Project Period:
2002 - 2003
Researcher Name:
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n/a
Co-Investigator(s):
Christiana E. Newhill, PhD

Abstract:
This study investigated the role of management practices as a contributor to male social workers' increased exposure to risk factors for client-related violence in mental health settings. These findings suggest a client's history of violence and gender, a supervisor's gender, and an agency's low level safety policy implementation increases the likelihood of case assignment to male practitioners, which can help elevated risk exposure to client-related violence in this setting. These findings have implications for practice, training, management and policy making.

Impact:
Some of this study's findings have been presented at local and national conferences (See below). These findings have implications for understanding gender disparities in client-related violence exposure, supervisory training, and improving NIOSHA recommended safety policies across mental health settings.

• Risk Assessment Methods •

Evaluation of Toxicologic Risk Assessment Models Using Epidemiologic Data

Project Period:
1998 - 2005
Researcher Name:
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University of Rochester (formerly with UNC)
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Abstract:
This project assessed the degree of concordance between risk predictions derived from animal-based models and those with the risks observed in epidemiological studies. This relationship is of significance because most risk assessments are based on toxicological data, but the validity of extrapolating from animals to humans has not been thoroughly investigated. In this project, a cooperative agreement was awarded to scientists at the University of North Carolina, who (in close collaboration with NIOSH scientists) evaluated the degree of concordance between animal-based and human-based risk estimates for International Agency for Research on Cancer-designated carcinogens. The results of this comparison will be published in the peer-reviewed literature.

Impact:
The results of this study provide support for the continued use of risk assessment models based on rat bioassay data for particulates when human data are not available. However, since the majority of the results have not yet been published, the full impact of the study cannot be determined at this time.

Update of Cohort Mortality Study of Railroad Workers Exposed to Diesel Exhaust

Project Period:
1996 - 2003

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Co-Investigator(s):
n/a

Abstract:
This project utilized information from epidemiologic studies of railroad workers exposed to diesel exhaust to develop a risk assessment model of lung cancer in relation to occupational exposure to diesel exhaust. The railroad workers' study was updated under an Interagency Agreement with the Department of Veterans' Affairs and a new data file was provided to NIOSH for analysis. An extensive uncertainty analysis was performed to assess the impact of errors in exposure classification on the estimation of risk. Results from the analysis suggest that exposure to diesel exhaust contributed to lung cancer mortality in the railroad worker's cohort.

Impact:
This study is one of the critical epidemiologic studies that have been used by NIOSH and other partners for quantifying the risks of lung cancer associated with exposure to diesel exhaust. The findings from this study support the findings from previous studies that exposure to diesel exhaust is a cause of lung cancer in workers. These findings will have strong implications for future risk assessments and evaluations made by regulatory and non-regulatory agencies.

Life Cycle Safety: An Intervention to Improve Construction Worker Safety and Health Through Design.

Project Period:
2001 - 2004

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Co-Investigator(s):
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DGI Ergonomics and Safety Leadership

Abstract:
This project documented and evaluated the development and implementation of a safety-in-design process during the programming and detailed design phases of a large capital construction project in the United States. This initiative brought together the owner, design firm, construction manager, and trade contractors in a mediated process in which these parties collaborated to assess and modify the design of a semi-conductor fabrication plant with the aim of reducing the risk to workers involved in the construction of the facility. Drawing on multiple data sources that included direct observation, document review, semi-structured interviews, and focus groups with trade workers, the university-based research team identified factors contributing and limiting the success of this initiative and identified design changes that reduced risks to construction workers on this project that required approximately 3.3 million construction labor hours and involved more than 2,400 craft workers during periods of peak construction.

Impact:
This intervention to promote construction worker safety through a mediated design process was the first large-scale initiative of its kind in the United States. The design firm involved in this project is considering the promotion of safety-in-design to enhance its competitive position in the industry. The prominence of the owner and design firm involved in this initiative may prompt other owners to consider adopting a comparable effort, and design-build firms interested in developing a safety-in-design process have approached investigators on the research team about their work. As a result of the strong interest expressed in this project, the research team organized and hosted an international symposium on safety-in-design attended by over 100 researchers and practitioners. This symposium brought together leading experts in the field and led to the publication of an edited volume showcasing leading research and practitioner work in the area of safety-in-design.

Conference on the Future Direction for Risk Assessment Methods

Project Period:
1999 - 2002

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United Auto Workers

Co-Investigator(s):
n/a

Abstract:
A conference titled "Risk Assessment Methods: Current State of the Science and Directions for Future Research" was held in August, 2000. The conference brought together prominent scientists in different areas of risk assessment methodology, such as epidemiology, pharmacokinetic modeling, dose-response modeling, and uncertainty analysis. These scientists presented papers on the current state of the science within their discipline and participated in working group meetings to define specific areas for future research to improve risk assessment methods. The papers and working group reports were published as a special edition of the journal Human and Ecological Risk Assessment, in October 2002.

Impact:
The published proceedings from this symposium serve as a roadmap for NIOSH and other agencies (e.g. EPA and NIEHS) for future funding of research in the area of risk assessment methods.

Comprehensive Evaluation of the Within- and Between-Worker Sources of Variation in Workers' Exposures as Assessed by Biological Monitoring

Project Period:
1997 - 2000

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Abstract:
Although intra- and inter-individual sources of variation have been characterized for a large number of airborne exposures to workplace contaminants, similar variation had not been investigated extensively for biological measures of exposure. A primary objective of the study was to compile a database to assess the within- and between-worker sources of variation in exposure for a wide a range of biomarkers. A secondary objective evaluated the impact of exposure variability on health-effects studies for multiple measures of exposure collected on the same group of workers. In particular, information about the sources of variation was used to assess the sampling demands required to minimize errors in assessing exposure. A final objective focused on evaluating heterogeneity in the intra- and inter-individual sources of variation in multiple measures of exposure across groups of workers employed at the same plant.

Impact:
Notwithstanding the advantages that biomarkers offer in assessing exposure, estimating workers' exposures from relatively few measurements could attenuate measures of effect due to the effects of intra-individual variation. Such findings underscore the importance of quantifying sources of variation in exposure to workplace contaminants to design optimal sampling strategies for both the control of hazards in the workplace and for studies evaluating risks associated with workplace contaminants.

Physiologically Based Pharmacokinetic/Clonal Growth Modeling: Predicting Cancer Potential of Chemical Mixtures

Project Period:
2001 - 2004

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Abstract:
The basic tenet of this research is that carcinogenic potentials of chemical mixtures can be predicted by an integrated approach involving physiologically based pharmacokinetic (PBPK)/clonal growth modeling of time-course glutathione-S-transferase π positive (GST-P) foci development and its temporal cellular and molecular indicators. Experimental work are still in progress; however, the following conclusions are drawn from the available data thus far: (1) Of the three chemicals studied in this project, hexachlorobenzene (HCB), 3,3', 4,4', 5 pentachlorobiphenyls (PCB126), and arsenic (As), arsenic appeared to show an "anti-carcinogenic potential" effect against the formation of GST-P foci during the relatively short experimental period of 8 weeks; (2) We have successfully incorporated into the PBPK model certain patho-physiological processes resulting from partial hepatectomy and chemical treatments to the F344 rats; and (3) We have refined our clonal-growth model to the point that time-course GST-P foci development from HCB/PCB126 mixture treatment can be successfully simulated.

Impact:
The exposure to multiple chemicals in the workplace and in our life is a reality and yet currently available techniques cannot keep pace with the need for assessing the carcinogenic potential of these chemical mixtures. In this project, we are taking the first step to develop a predictive tool for the carcinogenic potential of chemicals and chemical mixtures based on the integration of computer modeling and focused and shorter-term experimentation. The predictive power of such a tool will become more robust as more data sets are available such that the linkage of biochemical reaction network modeling can be achieved and quantitative structural activity correlation can be successfully utilized. This work is anticipated to be a significant contribution to the occupational health and safety of the American workers because the development of such a tool is expected to be an integral part of the cumulative risk assessment process.

The World Trade Center Evacuation Study

Project Period:
2002 - 2006
Researcher Name:
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Co-Investigator(s):
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Martin Sherman, PhD
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Abstract:
This CDC- funded study is designed to identify the individual, organizational, and environmental (building) factors that affected the evacuation from the World Trade Center Towers (WTC) 1 and 2 on September 11, 2001. The overarching purpose of this study is to inform policy and practice with respect to evacuation of employees from high rise occupancies.

Impact:
The preliminary results of this study are already having an impact. In NYC, an ordinance was passed last fall that requires a full building evacuation on an annual basis for all workplace high rise buildings. In addition, the fire safety managers will now have to be recertified as emergency action planners to ensure that their facility is prepared for any number of emergencies, including full scale evacuation. We are working closely with our colleagues in the Office of Emergency Management and the NYC Fire Department to develop the training curricular for these planners, and to develop a best practices policy and procedures manual for them to use as their guideline. This approach will almost certainly be adopted by many other major cities in the U.S.

Pilot Study on Cardiovascular Health in Faroese Whaling Men with Long-term Increased Exposure to Methylmercury

Project Period:
2005 - 2005
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Abstract:
This project plans to assess the feasibility of conducting population-based cardiovascular health examinations in the Faroe Islands from a pilot study of whaling men. It also plans to assess the association of current and past methylmercury exposure with clinical indicators of cardiovascular health in this group of men with long-term high-level exposures from contaminated seafood. Finally, the project intends to determine the feasibility and validity of serum biomarkers that may serve to elucidate pathogenic aspects of the potential associations.

Impact:
None to date; the study is not yet underway, as notice of funding and IRB approval were just recently received. This study will hopefully provide evidence on the cardiovascular and neurological effects of heavy methylmercury exposures.

• Social & Economic Consequences •

Adult Asthma as a Predictor of Work Loss and Disability

Project Period:
1997 - 2001

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Abstract:
Our goal was to quantify asthma-related limitations in the occupational arena but also in the context of a variety of activities. We assessed work disability, asthma-specific quality of life, and generic outcomes, such as physical functioning and depression and associated costs. Multi-factorial predictive models were to include: asthma-specific disease severity, variation in clinical management (subspecialty and non-subspecialty care), psychometric measures of self-assessed asthma status and control, general health status, and demographic characteristics. During the course of the study we increased the original cohort of subjects (who had originally been recruited through a random sample of physicians' practices) and strengthened the study by recruiting a supplemental sample of subjects recruited by random digit dialing. These subjects included both persons with a physician's diagnosis of asthma and persons with a diagnosis of chronic rhinitis only, without asthma. The final study cohort was comprised of 707 subjects.

Impact:
Our work helped increase awareness of the importance of work disability in adult asthma and rhinitis and has been cited widely by others (for example, first two publications listed below have 28 and 23 Citation Index notations). In terms of asthma cost, see accompanying editorial, DA Stempel. Assessing the economic burden of asthma. Journal of Allergy Clinical Immunology 2003; 111:1203-4 regarding our publication "A comprehensive study of the direct and indirect costs of adult asthma." Aspects of this work also helped raise awareness of the attributable risk of occupation in adult asthma (see for example the ATS statement on this subject: Balmes J, et al. American Thoracic Society Statement: Occupational contribution to the burden of airway disease. Am J Respir Crit Care Med 2003; 167:787-97). In addition, original instruments developed in this project related to asthma severity and perceived control have been adopted by others.

The Employment Impact of Workplace Injuries in Five States

Project Period:
1998 - 2002

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Abstract:
This study developed standardized methods to measure the impacts of workplace injuries and illnesses on employment and earnings. Data from 500,000 injured workers in five states were used. The study also quantified the impact on earnings when employers promote rehiring of injured workers. Finally, it developed methods for comparing average lost earnings among states that varied in important ways (e.g. industrial mix and unemployment rate) Both parametric and nonparametric methods were used to provide unbiased measures of the impacts of interventions.

Impact:
The studies emanating from this research played a central role in a book prepared by the National Academy of Social Insurance and published in 2004: Adequacy of Earnings Replacement in Workers' Compensation Programs, A Report of the Study Panel on Benefit Adequacy of the Workers' Compensation Steering Committee, H. Allan Hunt, Editor. W.E. Upjohn Institute.

Disability Risk in Work-Related Musculoskeletal Injuries

Project Period:
2001 - 2006

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Abstract:
The vast majority of the costs and lost productivity in workers' compensation are due to work-related musculoskeletal injuries. Among injured workers with these conditions, a small proportion (5 - 10%) develop long-term disability and account for most (80 - 85%) of the costs and lost work. In the absence of an accurate method to identify workers at risk for long-term disability, secondary prevention efforts cannot be well-targeted. This is a 5-year, population-based, prospective study of Washington State workers with work-related back injuries and carpal tunnel syndrome (CTS). The principal aim is to develop an accurate predictive model of risk for long-term disability from employment-related, biomedical/health care, sociodemographic, administrative/legal, and psychosocial factors present early after claim submission.

Impact:
This study has the potential to increase scientific understanding of factors that may contribute to long-term disability after a work-related musculoskeletal injury. We also hope to develop a method for accurately identifying workers with low back injuries and carpal tunnel syndrome who are at high risk for chronic disability. Such a tool could enable high-risk workers to receive an early intervention to promote recovery, including return to work. Identification of modifiable risk factors could inform efforts to prevent chronic disability. The study results have the potential to lead to recommendations regarding changes in workplace practices and in health care organization and workers' compensation policies to reduce rates of chronic disability.

Functional Limitations and Recovery From At-Work Injuries

Project Period:
1998 - 2001

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Abstract:
Problem: Two instruments, the Health Assessment Questionnaire (HAQ) and the Short-Form 36 (SF-36) were used to document both the immediate and short-term effects of workplace injuries in municipal workers.

Impact:
Both the SF-36 and HAQ were effective measures of functional limitations. Each independently predicted lost time

suggesting they measure different constructs. Substantial limitations and reduced quality of life persisted despite a 91% return to work highlighting the physical toll exacted on workers. The VASs of the HAQ added important information about fatigue, sleeping problems, and overall sense of well-being associated with injuries. This study reinforces the need for clinicians to more fully comprehend what recovery means to patients. Further more thoughtful research will help to clarify the role of functional evaluation in clinical settings and in constructing more effective treatment plans that assure optimal recovery for injured workers. As a result of this research, we have received pilot funding to further explore the effects of occupational injuries on family members of injured workers, an area only briefly explored in the literature.

Use of Health and Social Services Following Work Injury

Project Period:
2003 - 2005

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Abstract:
The pressure of coping with the consequences of a workplace injury affects workers and their family members, resulting in financial, emotional and psychosomatic trauma. This retrospective cohort study investigates the overall and mental health care use of injured workers (who filed a workers' compensation claim in 1994) and their family members in British Columbia (BC), Canada, using the BC Linked Health Data set (BCLHD). Injured workers were matched to a group of individuals in the population who were not injured (non-injured comparisons). We identified family members of these subjects and reviewed all data five years before and five years after the injury, with special emphasis on mental health care and social service utilization. Registration in the BC Medical Service Plan (MSP) and several workplace characteristics were controlled for in the analysis.

Impact:
A previous study, using the BCLHD to examine the health care and social service use of workers injured in 1991, found that injured workers were high users of health care services even before injury. The authors concluded that in order to understand this further, it is necessary to understand workers' early work experiences as well as their experiences before entering the workforce.

• Special Populations •

Casa y Campo: Pesticide Safety for Farmworker Families

Project Period:
2001 - 2005

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Abstract:
An estimated 4.2 million seasonal and migrant farmworkers and their dependents work across the United States. This population is largely minority (90% Hispanic), medically underserved, and at risk for a variety of environmental health problems. Casa y Campo is a community-university partnership of the North Carolina Farmworkers Project, Student Action with Farmworkers, and Wake Forest University School of Medicine that is working to reduce the environmental health risks of pesticide exposure among farmworkers in North Carolina. The Casa y Campo partnership has: (1) conducted research to

document knowledge and beliefs about pesticide exposure, to document exposure of farmworker children, and to document other environmental health concerns of farmworker families; (2) developed culturally appropriate materials and programs to reduce pesticide exposure among these families; and (3) developed materials and programs to better prepare health care providers to recognize, treat, and prevent pesticide exposure of farmworker families.

Impact:
Hundreds of farmworker families have received information and training on pesticide safety. With the completion of the health care provider education materials, a large number of these providers will be better informed about caring for pesticide-exposed patients. The involvement of the North Carolina Farmworkers Project (NCFP) has helped staff and community members to develop new skills. These skills are being applied to diverse health concerns. For example, NCFP has been instrumental in developing a proposal for a new migrant health clinic. The dissemination of study results in the areas of stress and mental health, food insecurity, and housing have been used by farmworker service providers and advocates to seek changes in existing programs and regulations. For example, project results documenting that the ability of farmworkers to call family members in Mexico reduces anxiety symptoms has led advocates to ask for telephones to be available in all farmworker camps.

Teaching Kids Safety on the Farm: What Works

Project Period:
2000 - 2003

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Abstract:
The 'Teaching Kids Safety on the Farm: What Works' study measured the impact of the active dissemination of the North American Guidelines for Childhood Agricultural Tasks (NAGCAT) to farm families on the rates of childhood agricultural injury. These guidelines were developed to help parents select age-appropriate farm tasks for their children and promote farm safety for children through increased awareness, simple behavioral changes, and increased adult supervision. In central New York State, 845 farm households with resident or working children were randomized to a NAGCAT intervention group or to a control group. Outreach educators visited each intervention farm household to explain, review, and leave a copy of the NAGCAT guidelines with the parent or adult employer. Control farms received a farm visit to collect baseline data only. Telephone surveillance was conducted every three months for both intervention and control farms for 21 months.

Impact:
The success of NAGCAT in reducing work-related child agricultural injury and delaying childhood ATV use is an encouraging start, but still only addresses selected sources of childhood agricultural injury. Because half of the childhood agricultural injuries recorded in our study were not NAGCAT related, it is unlikely that NAGCAT implementation alone can decrease childhood agricultural injury. Hazard reduction may be the next step because children on farms are injured not only while working, but also while being present while others work (such as preschoolers accompanying their parents during farm work), or using the farm workplace for leisure activities. Our study found that, when adjusted for hours working, children ages 0 to 6 years had an injury incidence density of 1.45, three times higher (3.15:1) than that of children ages 7 to 19 years (0.46, p=0.02). Involving pre-school in agricultural work places them at significant risk of injury.

Etiology and Consequences of Injuries among Children In Farm Households: A Regional Rural Injury Study - 1999

Project Period:
1998 - 2002

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Abstract:
The objectives for this study were: (1) to identify risk factors for agricultural operation-related injuries to persons less than 20 years of age, using a case-control study design and (2) to determine the incidence and initial consequences of injuries, for all persons, using an injury data collection system to serve as a basis for surveillance. Among 16,538 persons followed through 1999, approximately half were less than 20 years of age. Data for all types of injury events and demographics were collected for the two six-month periods of 1999 by computer-assisted telephone interview from a cohort of agricultural operation household members in a five-state Midwest region. Exposure data were collected, simultaneously, through a nested case-control study. Injury rates were adjusted for within-household correlation. Adjustment analyses addressed potential biases. Case-control data were analyzed using multivariate methods. Identification of the total injury burden for agricultural operations, and risk factors for agriculture-related injuries, suggest opportunities for interventions and further research.

Impact:
This study is the first such comprehensive effort to identify not only the magnitude and consequences of the agriculture-related injury problem in a large regional population, but also to identify risk factors for those injuries among children less than 20 years of age. All injuries, both agriculture- and non-agriculture-related, were included to address the total injury burden upon the agricultural community. This was accomplished through a rigorous scientific approach, including methods to minimize potential biases. Sophisticated analytical techniques were applied to optimize the risk estimates. The findings from this effort provide an important contribution to the knowledge of the enormity of the problem, and identity of specific risk factors that may assist in prevention and control efforts. Our results provide unique opportunities for further in-depth investigation of key risk factors and the most appropriate methods for controlling these factors.

Effects of Aging on the Biomechanics of Slips and Falls

Project Period:
2001 - 2004

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Abstract:
Injuries associated with slip and fall accidents pose a significant problem to industry, both in terms of human suffering and economic losses. Existing evidence has identified several aging effects related to slip and fall accidents, yet does not explain determining causes of older individuals' higher likelihood of slip and fall accidents. In this study, intrinsic changes associated with aging (e.g. gait adaptation, musculoskeletal and sensory degradation) and its effect on the initiation, detection, and recovery processes of slips and falls were evaluated to answer the question of why older adults were exposed to a higher likelihood of slip-induced falls. The aim of the study was to investigate changes in walking and the ability to recover from slips associated with increasing age. The present study measured how deterioration of lower extremity muscular strength/ activation rate, and sensory functions among older individuals affect several biomechanical parameters under normal and abnormal conditions.

Impact:
All subjects under slippery conditions slipped. However, the older individuals could not control their slips, leading to more falls. Thus, in a given situation, older individuals are at a higher risk for fall accidents (i.e., younger individuals can slip longer and faster and not fall). The prediction model further supports that vision, reaction time, and muscle strength (lower extremity) were important for determining slip and fall severity. Inability to control slipping responses may be a result of sensory degradation and muscle weakness. As such, possible intervention strategies (muscle strengthening and

balance exercises) can be important for improving dynamic equilibrium for the elderly. Furthermore, most of the current research on slips and falls concentrates predominantly on initiation of slips (i.e. RCOF), however, this study indicates that how slips result in a fall is important as well. Therefore, future research should focus not only on the dynamics of slips, but the dynamics of falls.

Factors Affecting the Health of Employed Pregnant Women

Project Period:
2001 - 2004

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Co-Investigator(s):
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Abstract:
Pregnant employed women may be at an increased risk for poor pregnancy outcomes and poorer postpartum emotional and physical health if they are exposed to high levels of prenatal occupational and home stressors. In this three-wave prospective panel study, 197 women employed full-time in non-professional occupations were interviewed at 28 to 40 weeks gestation, then again at 4-6 weeks (N=142) and 4-6 months (N=115) after their return to work postnatally. Data were analyzed via multiple regression with backward elimination. The findings have implications for changes in the organization of work for pregnant and postpartum non-professional women. Postpartum mental and physical health problems can lead to lost work time, low productivity, and increased use of health and community social services. Recognizing and trying to mitigate the effects of home and work stressors may reduce the drain on those resources, and, more importantly, improve the well-being of working mothers.

Impact:
While audiences at national and international meetings (APA, APA/NIOSH, APHA) have been shocked to learn how physically demanding these non-professional jobs are on women in their third trimesters, and how little paid maternity leave there is for women in these jobs, to my knowledge no policies have been implemented to address these issues. The findings of this study have implications for pregnant women working in a variety of service, clerical, and manufacturing jobs. Further research could examine the same issues in more professional settings, where the demands may change but occupational stressors may still operate. This study also suggests that both stressors and supports at home and at work need to be examined when dealing with health outcomes of working women (and perhaps of men as well). Looking only at workplace stressors may mask the relative importance of non-work related factors.

Sustained Work Indicators of Older Farmers

Project Period:
2001 - 2006

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Abstract:
This prospective panel study focuses on the family farmer, which is the most rapidly aging workforce in the United States. This special population suffers one of the highest rates of occupational injury and mortality. Specific aims are to (1) identify factors that influence the sustained work of farmers over age 50, (2) develop health profiles of older male and female farmers, (3) develop exposure profiles of agricultural tasks performed by older farmers, and (4) explore the sociocultural, family, and economic factors that influence the work practices and health of older farmers. 1,423 farmers in Kentucky and South Carolina were enrolled in the study. Measures on sociocultural, health and behavioral, and work environment factors are being collected through 5 seasonal waves of surveys and annual focus groups. Findings from the study will be used to design occupational counseling appropriate to age, gender, race, and health and safety programs for aging farmers.

Impact:
The results of these findings will be used to develop age appropriate programs for work organization of senior farmers and guidance for families of senior farmers. Of special

consideration is the difference and adjustments in gendered work patterns. Future work with economists, sociologists, and gerontologists is being planned. Emphasis on the retirement issues faced by older farmers will be explored in depth. Collaboration with The Work Centre in Ireland provided opportunity for comparison of work of older Irish and American farmers during a seminar presented at the Irish University, Dublin. This collaboration will continue to develop and test work interventions based on the findings from the two studies.

Adapting the North American Guidelines for Children's Agricultural Tasks (NAGCAT) for Ethnic Communities: A Research Model

Project Period:
2000 - 2004

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Abstract:
Hmong children work or play alongside their parents in the field and at the market. Current English-language safety materials do not include many tasks Hmong children are doing and are in a format not understood by non-literate Hmong parents. The purpose of this research project was to investigate culture-specific health behavior patterns and develop culturally-appropriate health promotion methods for Hmong farming families. Through field observations and other methods, the research team learned that the three primary hazards encountered by Hmong children include (1) rototiller operation, (2) use of knives and other sharp handtools, and (3) marketing activities (including money-handling, lifting, and customer interaction). This research resulted in the development of three culturally and ethnically appropriate guidelines. Methods and procedures were documented and shaped into an algorithm useful in adapting safety guidelines on ANY topic for ANY age and ethnic group with slight modifications in ANY part of the world.

Impact:
Although the Hmong community has many characteristics that make them "different" from mainstream American farmers and their families, they share more similarities than differences. The Hmong place great value in their children performing farm work, and they ultimately want to be able to control parental decision making. While they are receptive to safety messages from outside "experts", the intent and the delivery strategies (the types of messages, format, and intent/expertise of the presenter) are all very important. Our work with child agricultural health and safety in immigrant and refugee communities has continued because of this original project. Based on the knowledge, experience, and trust built in the refugee farming community, we have been able to secure additional funds to implement an injury prevention program demonstrating the hazards, control methods, and training necessary before three common and hazardous tasks can be safely assigned to Hmong children.

Health Disparities Among Healthcare Workers

Project Period:
2000 - 2006

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Abstract:
This study uses multidisciplinary methods to examine the work environment as a primary mediator of the effect of

socioeconomic position on health. We will estimate the degree and frequency of exposure to health and safety hazards in a large population of healthcare workers in northeastern Massachusetts and describe the context of these exposures within the organization and climate of the workplace. We will describe the general physical and mental health of participating healthcare workers and estimate frequency of musculoskeletal disorders, acute injuries (including interpersonal assaults), and symptoms of anxiety and depression. The persistence of health problems and a range of employment outcomes will also be assessed. Facility case studies will provide insights into the consequences of these health outcomes. By comparing multiple facilities and job groups, we seek to explain how the political economy of the work environment determines workers' health.

Impact:
Two healthcare worker health and safety conferences have been attended by 250 interested professionals and healthcare workers from New England. We have presented six training sessions to 50 workers (with 12 more scheduled for 120 workers), and supported increased ergonomics and health and safety awareness at facilities and within the MNA. Policy and research recommendations from our research include the need for (1) Coupling strong occupational health and safety with employee diversity support programs to prevent racial and ethnic occupational injury and illness disparities; (2) single jobs with livable wages and benefits to reduce cumulative exposures for healthcare workers; (3) further research on occupational injury and illness under-reporting among healthcare workers, in general, and by socioeconomic level; (4) a gender-conscious perspective in preventive, diagnostic, and restorative workplace interventions; and (5) further research about potential occupational injury and illness impacts from healthcare system changes which shift resources away from optimized care delivery and toward maximizing profit.

Evaluation of a School-Based Agricultural Health and Safety Curriculum: Work Safe Work Smart

Project Period:
2000 - 2004

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4.38 Rural Minnesota High Schools

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Abstract:
Rural adolescents may be employed in both agricultural and non-agricultural jobs. The Work Safe Work Smart curriculum was designed to address the wide spectrum of occupational hazards experienced by rural youths. The goals of this study were to evaluate the effectiveness of the Work Safe Work Smart curriculum by measuring changes in knowledge, attitudes, and beliefs related to preventative behaviors and to promote dissemination and utilization of the curriculum in rural schools. A group-randomized study design was used to evaluate the curriculum in a sample of 38 rural Minnesota high schools. A pre-test and two post-tests were used to evaluate outcomes. Adolescents exposed to the curriculum showed significant changes in five of the seven outcome categories at the first post-test and one outcome at the second post-test. Over 12,000 copies of the curriculum (whole or parts) have been distributed on CD-ROM and via download from the Minnesota Dept. of Health Web site.

Impact:
The Work Safe Work Smart curriculum was successfully implemented and evaluated in a sample of rural Minnesota high schools. Behavior-change theories such as the health belief model have identified several factors (such as perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and self-efficacy) as important to adopting healthier behaviors. The curriculum was designed to address these concepts in an occupational context, and the evaluation methods in this study were designed to measure changes in these factors. The findings demonstrated that the Work Safe Work Smart curriculum, under real-world conditions, did produce significant, if time-limited, impacts on several of these constructs. Following completion of the evaluation, over 4,000 copies of the curriculum were distributed on CD-ROM and the curriculum (whole or in parts) was downloaded over 8,000 times from the Health Department Web site.

Evaluating Teen Farmworker Education: An Evaluation of a High School ESL Health and Safety Curriculum

Project Period:
2000 - 2003

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Abstract:
The Teens Working in Agriculture English as a Second Language (ESL) curriculum is designed to provide teen agricultural workers with the knowledge and tools to protect their health and safety in the fields. The aims of this study were to assess whether high school students who participated in the curriculum would demonstrate increased knowledge and improved attitudes and behaviors regarding health and safety, and to assess whether a community-based intervention would increase outcomes even further. Using a quasi-experimental design, the research consisted of two intervention groups and a comparison group, and included over 2,000 students from some of California's key agricultural communities. Pre- and post-tests, focus groups, and interviews were used to evaluate the results among students, teachers and parents. The study found that a school-based ESL curriculum is an effective intervention to reach and educate teen farmworkers. ESL classes can serve as a much needed access point for young farmworkers.

Impact:
This study is unique in that it targeted hired teen farmworkers, and found that a school-based ESL curriculum is a successful intervention for reaching these workers and teaching them about occupational safety and health. The demographic findings will also contribute to creating a picture of hired youth in the fields. Presentations of the evaluation findings have met with enthusiastic response among farmworker advocates, who have expressed interest in adopting this curriculum in schools in their regions. Over 40 ESL teachers in California have received training and/or materials for use in their classrooms, and have demonstrated that this is a feasible approach that warrants further dissemination to the ESL instructor community.

Ergonomic Aspects of Older Workers' Postural Balance

Project Period:
1999 - 2003

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Abstract:
The main purpose of this project was to investigate: elderly (45-75 years) workers' abilities and limitations with regard to the work-related demands and associated task and environmental risk factors. The risk factors investigated were task type performed (static and dynamic), environmental lighting, standing/walking surface slipperiness and inclination and footwear hardness. The choice of risk factors and worker age groups were based on published epidemiological literature. Each worker's postural stability was quantitated using both kinetic and kinematic measurement systems in a laboratory where he/she was randomly presented with the above-mentioned risk factors. In addition, each worker's perceived sense of postural balance was measured and compared to that obtained by the objective measurements.

Impact:
The results from this study have provided useful scientific data to enhance an existing statistical model, based on industrial workers' data which demonstrated the relationship between postural instability and loss of balance potential and the independent variables characterizing the Environmental, Job-Task, and Personal workers' risk factors. The specific enhancements include such contributions as: effect of workplace risk factors (environmental lighting, surface slipperiness, footwear types and surface inclination) on the limits of older (>55 years of age) workers' postural stability/loss of balance during performance of various types of tasks. In future field studies, this statistical model can be used to help evaluate the postural instability and loss of balance potential by measuring, in a walkthrough evaluation, existing risk factors at the worksite. Availability of such models will have significant impact on identifying risk factors and prevent fall- related broken bones, spinal injuries, fatalities, permanent disabilities, lost work days, and medical costs.

Worker Susceptibility to Mutagenic Risk

Project Period:
2001 - 2005

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Abstract:
Special populations at risk for workplace-related health effects include workers with genetic susceptibility to the mutagenic effects of occupational exposures due to inherited variants of metabolism and repair enzymes. We have demonstrated that workers exposed to vinyl chloride (VC) experience an increased frequency of biomarkers of mutagenic damage (mutant ras-p21 or mutant p53) in a dose-dependent fashion. At any given dose, however, workers can experience none, one or both of these biomarkers, suggesting that inherited differences may exist that account for these differences in effect from similar exposures. Restriction fragment length polymorphism techniques were used to analyze DNA from subgroups of VC-exposed workers with none, one or both biomarkers of mutagenic damage for genetic polymorphisms in VC metabolism and repair enzymes. Workers with the polymorphisms would be anticipated to be more likely to have the biomarkers than similarly exposed workers without the polymorphisms and thus would be more likely to suffer from subsequent carcinogenic and other health effects of VC exposure and could be targeted for more aggressive interventions to prevent these adverse effects.

Impact:
If these results are substantiated in other studies, VC workers with these polymorphisms could be targeted for more stringent interventions to help prevent the occurrence of VC-related occupational disease. In addition, these results may have significance for workers with other mutagenic exposures because similar DNA damage is generated by other workplace exposures, XRCC1 participates in the repair of a wide range of such DNA damage. Because these polymorphisms are relatively common in the population, so large numbers of workers may be affected. Finally, the significance of this research has been widely recognized and disseminated because it was highlighted in the recent award-winning documentary film Blue Vinyl on the hazards of vinyl chloride, which has been shown several times on HBO and seen by an audience of millions.

Wisconsin Childhood Agricultural Safety and Health Intervention

Project Period:
1997 - 2000

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Various Wisconsin & regional fresh market vegetable producer organizations

Various national & regional fresh market vegetable producer trade publications

Various national and regional sponsors of grower trade shows and conferences

Co-Investigator(s):
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Abstract:
This project accomplished four specific objectives: (1) to learn about the work in the dairy and fresh vegetable market sectors in Wisconsin that children and adolescents typically performed and what musculoskeletal and traumatic injury hazards they faced; (2) to learn what has already been done to improve safety and health among working children and adolescents; (3) to evaluate practices that simultaneously increased profits and safety; and (4) to share the results with other state dairy producers and vegetable growers in an information dissemination intervention and evaluation effort. This research was adaptable on a wider scale and especially relevant to the "traditional agriculture" areas as well as elsewhere in the US. The practices are easy for farmers to adopt because they can be both safer and more profitable.

Impact:
First, our intervention translated research findings into standard practices throughout an industry. Interventions seeking to accomplish goals of this magnitude are rare in occupational safety and health. Second, we focused on child and adolescent injuries that targeted parents and other adult farm managers, who are best positioned to modify workplace hazards. Interventions that have taken this approach are uncommon in the existing research literature but hold great promise, especially compared to traditional approaches to childhood agricultural injury. Third, we conducted interventions that used media, events and other sources that the farm managers were already known to rely on. This was unusual for an injury intervention project, particularly in agriculture. Finally, we coupled safety and profit in the production practices that we promoted.

Safety interventions in agriculture and other industries have typically not incorporated this dual focus.

Work and Social Environments: Urban Youth and CVD Risk

Project Period:
1998 - 2002

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Pennsylvania State University

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Johns Hopkins University
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Abstract:
Cardiovascular disease is the leading cause of death in the US, and epidemiological studies have established that essential hypertension begins much earlier in life than was formerly thought (particularly among urban African Americans and Whites in lower SES groups). There is also increasing evidence that workers who are exposed to occupational stressors (high demand/low control), low social support, and emotional labor on the job are at risk for a wide range of negative health outcomes. Studies have not addressed these questions with adolescents and young adults who are employed part-time while in high school or as they pursue further education/work and are employed either part- or full-time. The impact of the work environment was viewed in relation to cardiovascular risk outcomes (ambulatory BP, body mass, cholesterol, triglycerides, serum glucose, and metabolic syndrome) along with important social and environmental contexts. The proposed study addressed the NORA priority area, Special Populations at Risk.

Impact:
The cohorts studied in this RO1 were originally eligible for study because they were determined to have high normal BP for race and gender compared to norms. Our results to date indicate primary support for the importance of job strain (control) in white young adults and emotional labor in male young adults as correlates of CVD risk. Overall these analyses point to the significance of negative emotions and interpersonal relationships as primary risk factors for both adult job stress and CVD risk, namely elevation in blood pressure. We also demonstrated that the findings in this sample are consistent with population trends with respect to the obesity epidemic in the US. Additionally, overweight was demonstrated to be a primary risk factor in this sample for future development of essential hypertension, CVD, and Type 2 diabetes mellitus. Ultimately, primary and secondary prevention programs need to be designed to reduce CVD risk as well as programs designed to assist young workers in the service sector and retail industries to manage anger as they interact with fellow employees, customers, and supervisors.

Green Tobacco Sickness Among Minority Farmworkers

Project Period:
1998-2002

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Wake County Human Services
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Abstract:
Green Tobacco Sickness is acute nicotine poisoning following dermal contact with tobacco plants. Most tobacco is harvested by migrant and seasonal farmworkers. The goals of this study were to: (1) estimate the incidence of Green Tobacco Sickness (GTS) among farmworkers employed in tobacco production in North Carolina; (2) determine the risk factors for GTS; (3) measure the association of tobacco exposure biomarkers with GTS symptoms and with work-related exposure to tobacco plants; (4) understand farmworker, farmer and health care provider interpretations of GTS; and (5) disseminate findings concerning GTS risk factors to farmworkers and service providers. This research included surveillance of 36 farmworker labor sites for one season, a case-control comparison of 60 clinical cases, in-depth interviews with farmworkers, farmers

and health care providers, and dissemination of findings about GTS risk factors to farmworkers and service providers.

Impact:
This study was the first to document the prevalence and incidence of GTS among minority farmworkers. It also documented farmworker beliefs about the causes and consequences of this occupational disease. Factors that increase the risk of GTS among minority farmworkers were also identified. These findings have been disseminated to farmworkers and health care providers. They have been used to develop health education materials for farmworkers (patient brochure, photonovela, instructional video) that are being used to help reduce the incidence of GTS. They have also been used to develop continuing education materials for health care providers (information in migrant clinician publications, continuing education workshops, an on-line continuing education program) so that they can better recognize, diagnosis, and treat GTS in minority farmworker patients.

• Surveillance Research Methods •

Capture-Recapture Estimates of Workplace Injury Rates

Project Period:
2002 - 2005

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California Commission on Health, Safety, and Workers' Compensation

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Wisconsin Workers' Compensation Division

Texas Dept. of Insurance

Washington Dept. of Labor and Industries

West Virginia Bureau of Employment Programs

New Mexico Workers' Compensation Administration

Minnesota Department of Labor & Industry

U.S. Bureau of Labor Statistics

Co-Investigator(s):
n/a

Abstract:
Accurate reporting of workplace injuries and illnesses is an essential component for determining prevention priorities. This study will provide improved estimates of the overall annual incidence of occupational injuries and illnesses for seven states: Oregon, Washington, Wisconsin, New Mexico, Texas, Minnesota, and West Virginia. The study will account for differential reporting by employer, injury, and worker characteristics. This also will enable the research team to identify factors associated with underreporting. On the basis of findings of the capture-recapture analysis, the investigators will suggest changes in reporting programs that would improve data collection.

Impact:
The study is still under way, and impacts cannot as yet be measured.

Injury and Illness Surveillance in Migrant Farm Workers

Project Period:
1999 - 2003

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Abstract:
Little is known about injury/illness in migrant farmworkers. This research estimated incidence of acute occupational injuries and prevalences of illness symptoms and workplace hazards, and identified predictors of injury. Followed for two years, the cohort consisted of 267 Hispanic families. Nearly 60% migrated, of which 95% completed follow-up interviews in 2000 and 2001. About 310 individuals each year participated in farm work on average 6 days/week, 10 hours/day, for 2.7 months each season. Reported injuries are substantial if person-time is taken into account. Twenty-five work-related injuries (first event) were reported. The overall injury rate was 12.5/100 FTE. Results from Cox regression modeling suggested increased risk for workers employed by contrac-

tors. Diversity of injuries (e.g. cut, fracture, contusion, strain, heat stroke, and skin rash) suggests targeting interventions at improving work conditions. Additional issues examined included chronic back pain, hand pain, compliance with Worker Protection Standard, and the use of maternal proxy respondents.

Impact:
This study and one conducted in California are among the only cohort studies conducted with migrant farmworkers. Also unique to this study, data collection involved interviewing participants in their permanent residence/home state. Both a report to participants containing pesticide safety information and a National Farmworker Health Line brochure were generated and distributed to participants. Because findings suggest collecting data directly from farmworker adolescents, a current project, "STARRS: South Texas Adolescent Rural Research Study" (Sharon P. Cooper, PhD; Principal Investigator), focuses on collecting occupational history and injury data directly from adolescent farmworkers to minimize underreporting bias from the use of maternal proxy respondents. Based on the prevalence of back pain among the adolescent farmworkers from this study and the lack of research in this area, the design of STARRS includes a considerable back pain component designed to identify factors associated with back pain in migrant farmworker adolescents.

Laboratory Reporting for Pesticide Illness Surveillance

Project Period:
1999 - 2004

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Abstract:
California's physician-based pesticide-illness tracking programs most likely underestimate pesticide illness rates. The purpose of this project was to assess whether laboratory-reported test results could enhance current methods of pesticide illness tracking. Three clinical laboratories voluntarily reported cholinesterase tests to CDHS. Test results were supplemented with medical records, follow up with physicians, and worker interviews. Abnormal tests were defined as those lower than individual baselines or below the lower limits of laboratory normal. Case incidents comprised all depressed cholinesterase performed within 30 days of another depressed cholinesterase result. CDHS worked with a variety of academic and state agency partners to assess the utility of laboratory reporting as a method for illness surveillance.

Impact:
We have recommended that a state interagency workgroup be established to explore the implications of this study. Among the issues to be addressed are: (1) modifications needed to make laboratory reporting an effective supplemental system to identify occupational pesticide exposures; and (2) mechanisms for evaluating the effectiveness of the CMP, potentially leading to revising regulations to improve medical monitoring for pesticide-exposed workers. This may lead to requirements for physician certification, worker notification, and medical evaluation. Findings from our study were considered by the State of Washington Department of Labor and Industries as they implemented a new worker cholinesterase monitoring program in 2004.

Evaluation of a Statewide Emergency Department Injury Surveillance System for Occupational Injury Surveillance

Project Period:
2000 - 2004

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Co-Investigator(s):
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Abstract:
Massachusetts Department of Public Health evaluated the feasibility of using electronic medical records from the Massachusetts Emergency Department Injury Surveillance

System (EDISS), a stratified sample of Massachusetts hospital emergency departments, to characterize occupational injuries treated in EDs in Massachusetts and to identify potential gaps in the traditional occupational injury data systems. The study aims were: (1) to estimate the sensitivity, specificity, and predictive value of two indicators of work-related injury in EDISS, (2) to assess the availability of information about employer, industry and occupation in medical charts and electronic systems of participating hospitals, (3) to estimate the accuracy of E-codes for work-related injuries, (4) to evaluate the feasibility of using two alternative coding protocols (Short ICECI and NEISS) for work-related injuries, and (5) to compare summary data on work-related injuries from EDISS and findings from the Massachusetts BLS Survey of Occupational Injuries and Illnesses to identify potential biases in findings from these alternative data sources.

Impact:
A number of states are developing statewide databases of emergency department (ED) records that can potentially provide useful information about occupational injuries as well as other injuries at the state level. This study explored the feasibility of using a statewide, electronic E-coded injury surveillance system for surveillance of work-related injuries. Findings indicate that a statewide ED-based injury surveillance system can serve as a powerful tool for conducting surveillance of occupational injuries. The study also identified a number to steps to enhance the utility of ED data for occupational injury surveillance. To our knowledge this is the first study to assess the accuracy of hospital E-coding of work-related injuries specifically. The finding of 85% accuracy of E-codes at the broad level typically used in injury surveillance was considered adequate for surveillance purposes, though there is room for improvement.

Occupational Health Surveillance of Low Income, Minority Populations through Community Health Centers

Project Period:
2000 - 2004

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Co-Investigator(s):
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Abstract:
Existing surveillance systems for non-fatal occupational injuries and illnesses provide little information about the occupational health experience of minority and foreign-born workers. We conducted a project to learn about the feasibility of surveillance through community health centers (CHCs), neighborhood-based providers of medical care and other services located in urban areas of Massachusetts. A waiting room survey was administered orally in five languages to 1,428 adult patients seeking care at five CHCs. CHC practices of routinely collecting data about patients' employment were also evaluated. The survey yielded valuable new information, however, developing systems for ongoing documentation of work-related health conditions at CHCs may be a more effective strategy to promote occupational health surveillance and services for underserved workers.

Impact:
The CHC survey yielded information about the occupational health experience of a group of workers about whom little is known: lower wage workers, including those from minority and immigrant groups, who use Massachusetts CHCs for their health care. The resulting data have generated interest among CHC staff and other stakeholders. Several CHCs have committed to future occupational health surveillance and intervention activities with MDPH in order to better meet the occupational health needs of their patients. Preliminary survey data regarding patients' awareness of OSHA and workers' compensation has been presented to OSHA and Department of Industrial Accidents representatives at state and regional meetings in order to encourage outreach to minority and immigrant communities. Several local non-profit groups and health and safety advocates, in partnership with participating CHCs, have used survey data as support for grant proposals for occupational health/environmental justice projects. Three participating CHCs have been funded as part of community-based occupational health initiatives.

Surveillance Methods for Healthcare and Related Workers

Project Period:
2001 - 2005

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Abstract:
Workers in the health care industry may be exposed to a variety of work-related
stressors including infectious, chemical, and physical agents; ergonomic hazards; psychological hazards; and workplace violence. The major objective of this project was to develop and implement a model surveillance system for health care workers (HCWs). Duke University Health System (DUHS) human resources job and work location data were used to define the DUHS population at risk. Outcomes and exposure data from existing occupational health and safety programs, health promotion programs, and employee health insurance claims, were linked with human resources data and de-identified to create the Duke Health and Safety Surveillance System (DHSSS). The surveillance system has successfully been used to study consequences of work-related stress, hearing conservation program evaluation, risk factors for back pain, and exposures to blood and body fluids (BBF). The DHSSS is being used for etiologic studies, benchmarking, and intervention program evaluation.

Impact:
One of the primary impacts of this project has been the realization of the programmatic value of a surveillance system that can integrate information across data sources to address specific problems. This system demonstrated overall improvements in the rates of BBF exposures across time, while revealing an ongoing problem in operating suites. This has led to additional studies to better understand BBF risk factors among operating room personnel. Our analyses of musculoskeletal injuries among nurses and aides have provided baseline data for the evaluation of patient lifting equipment recently purchased by the Duke University Medical Center. The surveillance system will provide data for a prospective evaluation of the effectiveness of this equipment and associated programs in the prevention of injuries. Data from our work stress analyses have been used to target work groups for stress management efforts.

Agricultural Injury Surveillance: Regional Rural Injury Study - II

Project Period:
2000 - 2004

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Abstract:
This surveillance effort was conducted among agricultural households (1) to: determine the injury burden for all injuries among all persons and risk factors for agriculture-related injury among persons less than 20 (<20) years of age; and (2) to monitor changes in data that were collected comparably, between 1999 and 2001. Totals of 16,538 and 16,064 persons were followed through 1999 and 2001, respectively: slightly more than half were <20 years of age. Data for all types of injury events and demographics were collected by computer-assisted telephone interview, from a cohort of agricultural operation household members, in a five-state Midwest region. Exposure data were collected, simultaneously, through a nested case-control study. Injury rates were adjusted for within-household correlation. Adjustment analyses addressed potential biases. Case-control data were analyzed using multivariate methods. Identification of the total injury burden, on agricultural operations, and risk factors for agriculture-related injuries, suggest opportunities for interventions and further research.

Impact:
This project was designed to serve as a model in the US for conducting surveillance of injuries among agricultural operations. A unique study design enabled data collection of the incidence and consequences of injury, through comprehensive interviews, and information about potential risk factors through the simultaneous application of a nested case-control study. Although there is some evidence in the literature about the magnitude of the agricultural activity-related injury problem among children less than 20 years of age, as well as adults, there is limited information about the risk factors for children, or how they change over time. Moreover, there has been limited information about the overall burden of injuries to agricultural households and related operations. These findings provide an important contribution to the knowledge of the enormity of the problem and identification of specific risk factors that serve as a basis for the development of prevention and control efforts.

Worker and Worksite Factors in Denver International Airport Construction Injury

Project Period:
2000 - 2004

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n/a

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Abstract:
Construction workers have high rates of work-related injuries and are among the most likely workers to experience serious occupational injuries. For this study, the combination of information from injury reports with an administrative database containing claims, demographic information, and hours worked provided a rich source of information for analyzing injuries and factors contributing to them. The data were evaluated to test hypotheses about factors differentially associated with different types of injury and different levels of injury severity. The data were also used to determine direct costs of injury for high-risk groups of workers and factors contributing to injury. Study aims were accomplished by coding and analyzing data from standardized First Reports of Injury (FRI) and Accident Investigation Reports (AIRs), linked with the administrative database for Denver International Airport (DIA) construction. We calculated injury and Workers' Compensation (WC) payment rates for factors contributing to injury for different injury mechanisms and types of work.

Impact:
The findings of this study led to another study evaluating various injury surveillance methods that we have undertaken at a large commercial construction site. This latter study attempts to elucidate cause of injury in detail using detailed interviews of injured workers. It also maps injuries and site conditions against the detailed construction schedule in order to get as complete a picture as possible of the possible factors that contribute to injury. The work on the initial study described above highlighted the need for more detailed information on all contributors to injury as well as information about the factors contributing most often to injury and those contributing to the most serious injuries. Our findings have informed the safety managers at the construction site for the research complex now being constructed at the University of Colorado Health Sciences Center at Fitzsimons.

Data from follow-up studies of injured construction workers

Project Period:
1990 - 2003

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Mechanical Contractors Association

Perini Construction

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Abstract:
In order to learn more about the causes of nonfatal construction worker injuries and to identify injury trends for further investigations and prevention programs, an emergency department-based injury tracking program was established in 1990. The program was motivated by (1) the high rate of non-fatal injuries in the construction industry; (2) the lack of specific information that describes the causes of these injuries; and (3) the lack of information that describes the short- and long-term impact of injuries on workers' lives. We abstracted demographics, diagnoses, causes-of-injury, and hospital discharge information for 3390 construction workers treated in an ED October, 1990 -December, 1998. We conducted follow-back telephone interviews with subsets of workers to further investigate injuries among Hispanic workers, eye injuries, falls, and musculoskeletal disorders (MSD).

Impact:
The impacts for this project included the following:

- We used multiple data sources to investigate injuries from pneumatic tools and pressurized vessels. We published a journal article and collaborated with NIOSH, CDPHE, CPSC, OSHA, and EPA to produce an Alert describing prevention measures
- We investigated an incident involving 5 workers poisoned by carbon monoxide from a gasoline-fueled

pressure washer. The employer discontinued use of gas-pressure washers in underground parking garages, and we publicized this hazard in the construction trades. Based on this report, CPSC began work on a series of warnings for this type of equipment.

- A large contractor association developed a new safety program focused on eye injuries based on this study
- The Sheet Metal Occupational Health Institute incorporated our findings into development of their health and safety training.
- The Center to Protect Workers Rights developed hazard alert pocket cards based on several of the key findings of this surveillance project. These cards are used widely in the construction industry in toolbox talks and other educational activities.

Partnerships in Surveillance and Prevention

Project Period:
2000 - 2004

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Abstract:
This study was a collaboration between the university researchers, public health officials, and workers' compensation (WC) insurers. The disparities in data available in the state-mandated WC systems and those available in the databases held by private insurers and self-insured companies were addressed. The feasibility and potential utility of WC claims data from multiple insurers into a common database for monitoring all types of WC claims was assessed. Upon successful merging of data from multiple insurers, differences were determined between disabling and "medical-only" claims among different insurers according to type of injury/illness, age and gender of claimants, and type of industry. Comparisons were made with state WC databases. This project demonstrated the utility of insurer databases in monitoring illness and injury trends and patterns of claims. The partnership provided insurers with new insights into their loss claim patterns. The project also demonstrated the barriers to meaningful merging of multiple insurer databases.

Impact:
Insurer databases have strong potential for improving our understanding of work-related injury/illness in states that do not have a centralized depository of all workers compensation claims. The results of this study outline the challenges that were encountered during the course of this work. We produced programming for converting NCCI Injury Codes to the OIICS Injury Coding System. Mechanisms for cooperating with state agencies to obtain employment data needed for rate calculation are needed. Consistent systems of ICD-9 coding by insurers would contribute to improved information. The confidentiality issues raised by the insurers are serious factors to consider in building partnerships. The identity of each insurer must be protected and the dissemination of information from the partnerships needs approval from all members.

Linking Occupational Injury and Illness Data Bases

Project Period:
2000 - 2005

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Abstract:
The current national surveillance for work-related injuries and illness is widely acknowledged to provide incomplete estimates. The investigators linked five work-related injury and illness surveillance systems for Michigan-related data: U.S. Department of Labor, Bureau of Labor Statistics (BLS) Annual Survey of Occupational Injuries and Illnesses, U.S. Department of Labor OSHA Injury and Illness Survey, First Injury and Illness Reports to the Michigan Bureau of Workers' Disability Compensation (BWDC), Occupational Disease Reports to the Michigan Department of Labor & Economic Growth (MDLEG), and U.S. Department of Labor Occupational Safety and Health Integrated Management Information System. The current national system was estimated to miss 66-69% of the occupational injuries and illnesses that occur

each year. A more comprehensive surveillance system would be useful for better documenting what percent of public health resources should be allocated to occupational safety and health, to prioritize, target, and evaluate both public health and enforcement activity.

Impact:
The results of this study suggest that BLS misses 49-69% of injuries and illnesses. This is consistent with studies that showed that BLS missed 50% of acute traumatic fatalities when deaths were estimated the same way injuries and illnesses are currently estimated. Possible solutions to address the BLS undercount include switching from sampling to a census, such as used by Mine Safety and Health Administration (MSHA), and/or using multiple sources, as BLS does for Census for Fatal Occupational Injuries (CFOI). The interim results from the BLS annual survey need to be adjusted upward to take into account the large BLS undercount of work-related injuries and illnesses.

• Traumatic Injuries •

Postural Stability Effects In Low Seam Mining Tasks

Project Period:
1999 - 2003

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Co-Investigator(s):
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Abstract:
The manual material handling tasks in underground low seam mines present a myriad of ergonomic risk factors, which place inordinate demands on the neuromuscular systems of miners. The overall purpose of the study was to quantify the postural instability of low seam miners while carrying out mine related tasks under exposure to the individual and combined risk factors of environmental lighting, surface condition and footwear used.

Impact:
The results allow enhancement of an existing model by adding the effects of new risk factors of restricted posture, glare, kneeling, task type and uneven/slippery surface, which are typical in low-seam underground mines. In future field studies, this statistical model may help evaluate the propensity for postural instability and/or loss of balance by measuring, in a walk-through evaluation, existing risk factors at the mining worksite and an appropriate intervention strategy can then be developed. Availability of such models may significantly impact risk factor identification during job and workplace analysis of mining sites. Based on results from this study, improved work practices/training can now be developed to reduce the likelihood of workers' slips/falls while working in low seam mines. These results can also be used to provide scientific data about postural instability under various combinations of workplace risk factors as input into the MSHA's human factors' training program software.

Electrical Arc Injury Parameters and Prevention

Project Period:
1999 - 2003

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Co-Investigator(s):
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Abstract:
The development of conceptual and three-dimensional computational models for electrical arc events and their use in severity rating blast conditions for triage and prevention is addressed in this project. Specifically, the correlation between numerical simulations of acoustic forces and experimental data is expected to result in improved safety standards for electrical work practices around energized equipment. Hazard management of electrical arcs' acoustic component has not routinely been incorporated into electrical safety training. This project is essential to address the lack of data and analysis around the interaction of acoustic forces and workers during electrical arc events so that prevention strategies can be implemented. In part, blast effects may explain why electrical injury patients without external signs of electrical contact may have nervous system or hearing impairment. Information to be developed in this project is expected to serve as the foundation for future clinical and workplace recommendations.

Impact:
Our research progress is influencing US medical, electrical engineering, and electrical safety management by encouraging multi-disciplinary, cross-functional, and inter

organizational collaboration acknowledging the "multi-hazard nature" of an electrical arc accident. By linking the basic science appreciation of injury as a resultant of energy transfer to the body, to electrical inputs and outputs in an electrical accident, we are creating awareness of an electrical arc as an "electro thermal chemical" or ETC event; and advancing safety by returning programmatic focus to classical considerations of industrial hygiene principals of electrical energy dosimetry depending on the frequency spectrum of the energy, and depending on the dose magnitude and rate. There is heightened interest in the incorporation of surveillance protocols using rapid response sensors and fiber-optic signal transduction to revisit engineering assumptions predicated on data acquired with 20th Century technologies. This trend is promising for re-calibrating ideas of "acceptable" electrical arc exposures.

Wisconsin Dairy Traumatic Occupational Injury Intervention

Project Period:
2001 - 2005

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various national and regional dairy trade publications

various national and regional sponsors of dairy trade shows and expositions

Co-Investigator(s):
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Abstract:
We are accomplishing three specific aims in this project: (1) Continue, for 3 additional years, a community-based, information-dissemination intervention among 21,000 Wisconsin dairy producers that will reduce traumatic injuries by persuading operation managers to adopt safer and more efficient work methods. The investigators will reduce hazards (and thereby injuries) by improving information flow to dairy operation managers to persuade them to adopt production methods that are both safer and more profitable. (2) Conduct annual, large-sample, mail questionnaire evaluations to determine whether (a) our materials are reaching the target audience and which intervention aspects are most effective, and (b) dairy producer adoption and awareness of each production method have increased. (3) Add one or two traumatic injury-reducing production methods to the intervention after seeking out reports from farmers and others about emerging production methods.

Impact:
This work was innovative because the intervention: (1) promoted engineering controls by substituting safer and more profitable practices, (2) intervened with a relatively large subject population of thousands of operations, (3) utilized the full range of existing information channels for farmers, and (4) evaluated the intervention at baseline and after each year over a multi-year time frame. In most industries, many managers continue to rely on "older" production practices despite the ready availability of more efficient, less costly and less hazardous practices. Often, what appears to stand in the way is a lack of awareness on the part of firm managers about the existence, value, and ease of use of the improved practices. This is at least in part attributable to the absence of convincing, comprehensive, and well-targeted interventions to optimize information flow. Our research results provide evidence that better information flow is associated with increased adoption of safer production practices.

Evaluation of Traumatic Injuries in Healthcare Workers During

Project Period:
2001 - 2005

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Abstract:
There are over 8 million health care workers (HCWs) in the U.S. and approximately 600,000-1 million needle sticks occur resulting in 1000 new cases of HIV, HBV, HCV among HCWs. Recent increases in the rate of needlestick/sharp injuries and exposure to bloodborne pathogens has been reported to be greater than 50% in HCWs who work in the operating room (OR) as compared to other HCWs in other settings. Thirty-three percent of the injuries occur in the surgical field, 25% occurring at the surgical site, 59% occurring with the non-dominant hand. This study investigated: (1) the factors associated with needlestick/sharp injury during a surgical episode and (2) evaluated specific surgical factors that impacted on the rate of traumatic (needlestick/sharp) during surgery. Data were collected in two phases: (1) HCWs involved in the study using an indicator glove to detect sharp injuries and (2) HCWs using bunt needles engineered to reduce the rate of needlestick/sharp injuries.

Impact:
Although the use of an indicator glove system to detect needlestick injury would seem appropriate for clinical use, our data demonstrated that double gloving provides the same protection. This is an important finding since HCWs can adopt double gloving practices without having concern about additional protection. Second, the use of a blunt needle may be a more important finding. Aspects of the factors associated with the use of a blunt needle will provide better worker safety in the operating room. Although our data has not been analyzed, the impact of the use of blunt needles may change the basic operating room "standard of care" associated with the use of sharp needles for routine surgery.

Work-Site Intervention to Reduce Work-Related Assault Injury

Project Period:
1996 - 2001

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Co-Investigator(s):
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Abstract:
Homicides and assaults have increased in the workplace. The major objective of this study was to determine the effectiveness of a community-based, business-site educational intervention to reduce work-related assault injury in high-risk business populations. The intervention program was developed to meet the individual needs of each business. Other objectives included identifying risk factors for workplace assaults, describing the incidence of workplace assaults in selected communities, and identifying specific environmental changes or groups of changes that decrease workplace violence. Additionally, the project identified and examined emerging trends, and correlated the level of individual store compliance to the intervention program with workplace violence event rates. Several important collaborations established in the course of the study will assist in further dissemination of the program.

Impact:
The Workplace Violence Prevention Program provides important information that is not widely available to small business owners. Because this is one of the first federally-funded projects to develop and implement such a program, and since it does appear to be effective, we felt it was very important to make efforts to increase the availability of the program. Thus, we made several important collaborations that will assist with further dissemination of the program: Korean American Grocer's Association; Oxnard Police Department; Cal/OSHA Consultation Services; and the Los Angeles Police Department. All of these organizations have received some training and materials to assist them in continuing to provide the project's important prevention information.

Risk Factors For Violence Among Nurses

Project Period:
1998 - 2002

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Abstract:
A total of 6,300 Minnesota nurses (registered and licensed practical) were randomly selected from the 1998 licensing databases and surveyed to determine employment and occupational violence experience. In a nested case-control study, relations between environmental exposures and physical assault were examined. Cases of assault in the previous 12 months, and controls randomly selected from assault-free months, were surveyed about prior-month exposures. After adjustment by multiple logistic regression, incidence of physical assault was 13.2 per 100 persons per year (95% confidence interval [CI]=12.2-14.3). Among 310 cases and 946 controls, odds ratios for assault were increased: in nursing homes or long-term care facilities, emergency, and psychiatric departments; in environments not "bright as daylight"; and for each additional hour of shift duration. Risks were decreased when carrying cellular telephones or personal alarms. These results may guide in-depth investigation of intervention efforts to control violence against nurses.

Impact:
This study is the first such comprehensive effort to identify not only the magnitude of the violence problem in a major occupational population but, also, to identify specific risk factors for work-related physical assault. This was accomplished through a rigorous scientific approach that included validation efforts to facilitate analyses of potential biases. Sophisticated analytical techniques were applied to optimize the risk estimates. As a result, the findings from this effort provide an important contribution to the knowledge of work-related violence and, particularly, provide information on specific risk factors that serve as a basis for the development of appropriate prevention and control efforts. In addition, results of this effort provide unique opportunities for further in-depth investigation of key risk factors and the most appropriate methods for controlling these factors in various health care settings where personnel are at high risk for violence.

Surveillance Research Methods in Construction Injury

Project Period:
2002 - 2006

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Abstract:
Construction workers have among the highest injury rates, yet significant challenges remain in understanding their work exposures and associated injuries, for reasons associated with the way they work. Construction workers are mobile and work for multiple contractors, making them difficult to enumerate. Their job sites constantly change as do associated hazards. The work is often done by multiple trade groups with different responsibilities, different immediate supervisors, different safety priorities and training requirements, and different compensation carriers. We are evaluating several injury surveillance methods, including gathering detailed information about occupational injuries, observing hazards, and collecting information directly from workers on a long-term commercial construction site with a diverse workforce. Data have been collected through a combination of quantitative and qualitative methods. The result should be an improved understanding of workers' injury experience as well as the context in which injuries occur on complex construction projects, information useful for guiding prevention efforts.

Impact:
Since the project is in the data analysis stage, impact cannot as yet be measured.

Evaluation of Workplace Violence Prevention Intervention

Project Period:
2002 - 2007

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Abstract:
Workplace violence is pervasive in the social service and health care settings. The program will be developed in concert with Federal OSHA guidelines for violence prevention. Management commitment and employee involvement are inherent in the design of the proposed study and include the formation and work of joint labor-management advisory groups. The aims of the proposed five-year project are as follows: (1) describe environmental, organizational, and behavioral/interpersonal risk factors for workplace violence present in the social service workplace, (2) assess the assault experience of staff in these workplaces, (3) examine the relationship between organizational factors and staff assaults in this sample of workplaces, (4) design and implement a violence prevention intervention within these workplaces, and (5) conduct a process and outcome evaluation of the intervention in sample workplaces one year following program implementation.

Impact:
Qualitative data collection is to be completed in Spring 2005. To date, the impact of the project consists of engaging management and front-line workers in the violence prevention worksite analysis.

Disaster Recommendations for Emergency Worker Safety & Health

Project Period:
2001 - 2003

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Co-Investigator(s):
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Abstract:
Responding to major disasters – including large-scale accidents, civil disturbances, natural disasters, and terrorist attacks – poses high risks to emergency responders. In an effort to better understand the risks inherent in these incidents, NIOSH collaborated with RAND to study safety management during disaster response. The research effort studied responses to the 9/11 attacks (World Trade Center and Pentagon), the Anthrax incidents in Florida, Hurricane Andrew, and the Northridge earthquake. The NIOSH-RAND team conducted over 75 interviews with individual responders, reviewed disaster response literature, and conducted a workshop with emergency responders and managers to discuss disaster safety management issues. Analysis of these data demonstrated that safety systems optimized for smaller incidents, groups of more uniformly trained and equipped workers, a small number of response agencies, and more predictable hazards do not effectively scale up for catastrophic events. NIOSH and RAND jointly published and widely distributed a report with recommendations for improving disaster safety management.

Impact:
Study findings have informed the development of the National Incident Management System (NIMS) and the National Response Plan (NRP), and the development of the Worker Safety and Health Annex of the NRP. The NIOSH-RAND report has been widely distributed to managers and policymakers at all levels of government with emergency management, disaster response, and worker safety responsibilities. The recommendations have also been disseminated to academic institutions with emergency and disaster management degree programs, and associations and unions that represent emergency managers and responders. The report has received an overwhelmingly positive response, based on the return of approximately 200 reader response cards. Ninety-two percent plus of those responding indicated that they are using the information and recommendations to inform planning, change programs and curricula, and implement specific recommendations. Most of those who have returned the reader response cards are emergency management directors/administrators at local (county or municipal) levels.

Etiology of Injury in Drywall and Residential Carpentry

Project Period:
1998 - 2002

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Carpenters Joint Apprenticeship Training Program
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Dennis Patterson
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Abstract:
Construction workers have high rates of work-related injuries. This research sought to determine if active injury investigations could identify causes of work-related injury among carpenters and specific risk factors for back disorders that result in prolonged loss of time from work. The investigators: (1) identified a cohort of drywall and residential carpenters to participate in a prospective study of the etiology of workplace injuries; (2) developed methods for reporting injuries, systematic collection of data from injury investigations, and analyses of both coded and descriptive data; (3) conducted both rate-based and case-based analyses of injuries among the defined cohort of drywall and residential carpenters; and (4) demonstrated the use of these prospectively collected data in exploring risk factors for prolonged loss of time from work following back injury using a case-control design.

Impact:
The Carpenters Joint Apprenticeship Program in St Louis, Missouri instituted a nail gun training program for early apprentice carpenters based on study findings. To our knowledge this is the only formal training program that addresses safe use of these tools. A new grant is evaluating the effectiveness of the program.

Workplace Violence Risk in Home Health Workplace

Project Period:
2002 - 2005

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Co-Investigator(s):
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Abstract:
Workplace violence is recognized as a significant occupational hazard in the healthcare sector, however little is known about the magnitude of the problem and effective prevention strategies in the home healthcare workplace. The overall objective of this exploratory research project was to collect pilot data to inform study design, sampling strategy, and measurement of workplace violence in the home health workplace. The pilot project developed measures for risk factors, threats and assaults, and current violence prevention strategies. This project also developed measures to assess current violence prevention strategies in home health and their coherence with OSHA's violence prevention guidance for home healthcare. The study used a mixed method cross-sectional design using focus groups, expert content reviewers, cognitive interviews, and a self-administered survey of visiting home health workers at four home health programs (n=130). This pilot project provided a conceptual and methodological blueprint for a large-scale investigation of workplace violence in home healthcare.

Impact:
The HVRS and EVPS demonstrated preliminary evidence for reliability and validity. These scales should be utilized in a representative sample of visiting home health providers. The findings also support conceptualizing home visit risk as a psychological job demand and employer violence prevention as a social support thus demonstrating that the Job Demand model holds theoretical promise for future workplace violence research.

Work-Related Assault: Impact of Training and Policy

Project Period:
2001 - 2003

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Abstract:
Work-related violence is a serious problem. While policies and training are recommended as part of a comprehensive approach to address occupational violence, little empirical literature exists to support this recommendation. The purposes of this study were to examine the relationship between (1) work-related violence prevention policies and (2) work-related violence prevention training, and the outcome of work-related assault against nurses. Data were collected as part of the Minnesota Nurses' Study, a two-phase population-based study of 6,300 nurses. A comprehensive causal model, using a directed acyclic graph, served as a basis for survey design, analyses, and interpretation. Sensitivity analyses were also incorporated regarding unmeasured confounders and exposure misclassification. Zero tolerance policies, and policies about types of prohibited violent behaviors may be protective in this population of Minnesota nurses, while the effects of violence prevention training appear to vary by topic. This study serves as a basis for future research.

Impact:
Certain types of violence-prevention policies, specifically zero tolerance policies and policies that address types of prohibited violent behaviors, appear protective in this population of Minnesota nurses. Regarding training, an increased risk of physical assault was identified for nurses trained in managing assaultive/violent patients at the univariate level; however, at the multivariate level, no statistically significant results remained. This lack of protection from training is consistent with previous research; however, the reasons for this lack of effect are unclear. In order to more thoroughly understand the impact of policies and training on occupational violence, additional research is necessary. Policies should be physically reviewed to better understand specific components included within each policy, and further details on training are needed, such as training content and methods. Work-related violence is a serious problem, and an urgent need exists to more fully determine the impact of violence prevention training and policies.

Auditory Motion and Pedestrian-Motor Vehicle Collisions

Project Period:
2002 - 2004

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Abstract:
The objectives of this research were to identify the specific acoustic conditions that maximize the perceptual bias to hear looming motor vehicles as closer than actual, thereby giving workers more time than expected to avoid collision. These results could then be used to enhance pedestrian safety through the use of temporary pavement treatments that take advantage of auditory perceptual biases. A series of experiments showed that (1) approaching vehicles that produce a modulated tone provide a greater margin of safety than either a constant tone or broadband noise, (2) as approach velocity increases, the margin of safety bias is greatly diminished, (3) at slower approach velocities, men are at significantly greater risk than women because women exhibit a greater anticipatory bias, and (4) the disparity in the anticipatory bias between men and women diminishes with increasing velocity, putting both sexes equally at risk for fast approaching vehicles.

Impact:
The current work has advanced our knowledge of auditory looming perception, a key skill necessary for avoiding approaching vehicles in the workplace. Specific recommendations include incorporating temporary pavement treatments in highway construction zones that create modulated tones when vehicles pass over them. These same strategies might also be employed in heavily traveled pedestrian crosswalks.

Evaluation of California Initiatives to Reduce Violence in Healthcare Settings

Project Period:
2002 - 2005

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Abstract:
In response to a growing awareness of violence against health care workers, the State of California implemented two initiatives, one regulatory and one legislative, to reduce violence in health care facilities. This quasi-experimental study evaluates the simultaneous effects of these two initiatives. The first objective is to conduct an impact evaluation to determine whether the initiatives led to improved security programs in California hospitals compared to control hospitals in New Jersey, which enacted no new initiatives. The second objective is to conduct an outcome evaluation to determine the effects of the two initiatives on decreasing violent event rates. Security programs are assessed through review of program material and multiple on-site interviews, and violent event rates are collected using the participating hospital's ongoing reporting systems. An interrupted time-series analysis will be used to determine whether the initiatives led to decreases in rates when compared with the comparison hospitals.

Impact:
Although no formal results are available, this project has already had impact among the participating hospitals. Following the murder of a psychiatric worker in California, the study team called together a symposium for the hospitals participating in the study. Every participating hospital sent at least one representative. The symposium, held at the California Department of Health Services, Division of Occupational Safety and Health, provided preliminary findings from the study and allowed participants to share success stories and strategies for security programs. In our final year of the study, we will conduct several more such symposiums.

Slip Trip and Fall in Construction and Transportation

Project Period:
1999 - 2002

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Co-Investigator(s):
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Abstract:
The focus of this effort was to develop a general understanding of the mechanisms of falls and slips on an unimproved surface. If these injuries can be controlled through engineering controls, future work will be directed toward testing of these controls. Information on the mechanisms of falls in this environment is currently limited. Possible engineering control approaches include specific work boot sole designs and modification of soil modulus and strength through the addition of fibers. The implementation costs would be modest and could have significant financial impact, particularly when viewed from the perspective of a human capital approach. A system was developed to predict the impact of some of the engineering controls on the mechanics of walking. A small-scale study of some soil additives was conducted. Variability of the response resulted in a need to consider alternative models for testing in the early stages of development.

Impact:
Given the preliminary character of this research the workplace was not impacted directly. Instead, the research began a process which is ongoing looking at the strain sensitivity of different soil surfaces. In particular, the strain sensitivity of soil surfaces from the horse racing industry have been investigated. This has allowed the work to continue with a higher load and more controlled surface properties. Extrapolation into the reduction of workplace injuries will allow further leveraging this continuing research.

Risk Factors for Occupational Knee Injury and Disability in the U.S. Army

Project Period:
1999 - 2001

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Abstract:
Using the Total Army Injury and Health Outcomes database, we completed case-control comparisons of occupational knee injury and knee-related disability in the U.S. Army. Separate comparisons were nested in the population of U.S. Army personnel, 1980-1997. Aims: (1) identify predictors of occupational knee-related disability; (2) demonstrate that related case-control comparisons can identify differences in determinants of causally related outcomes (injury and related disability); (3) demonstrate that administrative data offer a cost-effective resource. Results: we found non-white men and women had 30% lower risk than whites for injury and disability. Age was associated with both outcomes for women, and with disability for men. Other associations differed by gender and outcome. Conclusions: Gender-stratified logistic regression models showed independent contributions of sociodemographic and occupational characteristics to risk. Administrative data were effectively used for separate case-control comparisons that identified risk factors for related outcomes.

Impact:
Identifying occupational risk factors for knee-related hospitalization and disability among Army personnel may be helpful in reducing the risk of future knee injuries and disabilities. Such risk factors may be modifiable by implementing changes to work tasks, training, equipment or job assignments. Interactions between occupational and demographic characteristics suggested there may be subgroups within certain job assignments that are more susceptible to injury or disability than others. If so, then a targeted evaluation of the adequacy or appropriateness of equipment, training, or job assignments could increase the efficiency of future intervention efforts. These analyses also demonstrated the utility of administrative data for analytical research. The complexity of the analyses we were able to carry out, and the rich variety of results obtained, show the cost-effectiveness of using existing data for analytical epidemiology. This approach should be considered a reasonable alternative to other, more expensive research paradigms.

2 Cooperative Agreements

• Intervention Effectiveness Research Methods •

Evaluation of Exposure Control in the Autobody Industry

Project Period:
2000 - 2003

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Abstract:
In 1995, the EPA, OSHA, NIOSH, and members of the automotive refinishing industry pursued feasible and effective approaches to reducing the risk to the environment and to the safety and health of workers during automotive refinishing operations. On the basis of the problems identified, NIOSH developed recommendations for the automotive refinishing industry involving respiratory protection, engineering controls, and types of spray equipment used for controlling worker exposure to air contaminants in the facilities. The present research program conducted a systematic evaluation of the exposure control in the automotive industry by (1) describing and developing a baseline of current recommended exposure reduction work practices in the New Orleans metropolitan area for painters in automotive body shops and (2) implementing the exposure control matrix recommendations in select automotive body shops and assessing the effectiveness and efficacy of the exposure control matrix intervention in reducing health risks and enhancing painter safety.

Impact:
The present study had an important impact on the autobody shops that participated in the research. Although the sample was small, the workers who participated in the respiratory training showed improvements in knowledge and behaviors associated with proper utilization and care of respirators.

Further, most facilities do not have a set protocol for changing their filter and rely heavily on personal judgment. Results from the current study suggest that establishing a filter life expectancy in terms of booth hour or days could make for easier and possibly more accurate filter maintenance/changing protocol.

On a broader level, the current study also presents a systematic framework for evaluating compliance with the matrix. Thus, standardized measures were developed may be used for comparative purposes to assess compliance in other regions. Further, the present study provides evidence of the effectiveness of a multidisciplinary approach for evaluating worker health and safety that integrates behavioral science and epidemiological methods with the traditional industrial hygiene approach.

• Surveillance Research Methods •

Connecticut Occupational Disease Surveillance Enhancement Project

Project Period:
2002 - 2005

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Abstract:
The primary objective of this project was to improve the overall completeness, timeliness, and continuity of occupational disease reporting in Connecticut. We achieved our objective through focused activities including (1) assessing the completeness of reporting for occupational asthma, burns, and skin disease through comparison with existing data sources, (2) assessing the knowledge, attitudes, and practices of non-occupational medicine physicians, as they relate to occupational diseases and reporting requirements and targeting interventions to stimulate more complete reporting from primary care physicians (PCPs), (3) assessing the internal and external capacity for future development and implementation of a NEDSS-compliant electronic reporting system for occupational diseases, (4) identifying factors that influence the continuity of disease reporting from occupational health clinics and developing interventions aimed at ensuring continuity of reporting from individual clinics, and (5) enhancing processes for disseminating occupational disease information to appropriate partners and identifying and addressing ongoing and emerging occupational health issues.

Impact:
The major impact of this project has been in the areas of education and information dissemination and enhancement of our existing surveillance system. The process of identifying non-occupational physicians in the state has allowed us to distribute packets of information to these physicians regarding the requirements and processes for occupational disease reporting. Connecticut has also been participating in the piloting effort for the NIOSH/CSTE-sponsored Occupational Health Indicators Project, which has allowed us to compile this data on an annual basis and distribute summary reports to stakeholders on a regular basis. We have also begun development of a NEDSS-based electronic reporting system and expect to begin piloting this system in occupational health clinics in 2005. Communications with our partners within and outside of Connecticut have been enhanced through development of the Connecticut Occupational Health e-News newsletter, which provides surveillance data, safety tips, intervention tools, and worker education on a quarterly basis.

3 Intramural Projects

• Allergic and Irritant Dermatitis •

Quantitative Structure Activity Relationship Modeling

Project Period:
2000 - 2006

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Co-Investigator(s):
n/a

Abstract:
The project was designed to develop Quantitative Structure-Activity Relationships (QSARs) for occupational dermal exposures. It focuses on QSARs for allergic contact dermatitis. These goals are achieved by using standard QSAR methods augmented by original and innovative non-linear and non-parametric techniques. The project makes intense use of internal and external data and provides the program with a deeper understanding of the mechanisms by which chemicals trigger dermatitis. This capability allows predictions to be made of the activities of chemicals which have not been tested directly.

Impact:
The project's main outcome: QSAR models of skin sensitization will be included in the NIOSH policy for skin sensitization risk assessment. This policy is currently being developed under the NORA Dermal Exposure Program project: "Development of Decision-Making Procedures and Documents". It is expected that the binary model(s) developed will be used in risk assessment for hazard identification, and subsequently the continuous model will be used for dose-response assessment, exposure assessment and risk characterization. Additionally, the availability of extended compilation of chemical substances tested in LLNA, and computer models based on such data will provide additional and much needed information to industrial hygienist and other stakeholders to help them in their decision-making process. This could lead to considerable cost savings and reduced time for assessment of chemical hazard and more importantly for the filling of data gaps.

NORA DERM: Development of Decision-Making Procedures and Documents

Project Period:
2000 - 2006

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US Environmental Protection Agency

US Department of Labor, Occupational Safety and Health Administration

Co-Investigator(s):
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Abstract:
NIOSH estimates that 42% of the United States workforce is at risk of skin exposures to hazardous chemicals. Yet there are no consistent policies to evaluate the potential of chemical substances to provoke adverse health effects by route of skin contact and to alert workers and employers of the presence of skin exposure hazards. This project is part of the NORA Dermal Exposure Research Program. The overall goals of this project are (1) to develop documents to set forth NIOSH policy and recommendations for the identification of chemical substances causing systemic toxicity via dermal uptake, skin irritation and corrosion, and sensitization (allergic contact dermatitis) and (2) to disseminate information on the effective actions for reduction and control of occupational skin exposures. An improved NIOSH policy incorporating a decision-making process and supporting scientific criteria has been developed for the assignment of skin notations and will be applied to chemical substances with a Recommended Exposure Limit.

Impact:
A new NIOSH policy for update and revision of skin notations has been developed. This policy provides a new system of identifying dermal hazards and alerting the workers and employers of potential adverse health effects due to skin exposures to hazardous substances. Providing the revised skin notations will increase workers' understandings of occupational skin diseases and needs for protection, thus reducing potential harmful exposures. The Recommendations of Chemical Protective Clothing (CPC) under development for inclusion in the NIOSH Pocket Guide to Chemical Hazards will further supplement the new skin notations and will provide information on the use of CPC to protect workers and to reduce occupational skin diseases. The outputs of this project will ensure the control and management of occupational skin exposures and increase relevant knowledge.

Developing Dermal Policy Based on Lab and Field Studies: Coordinating Core

Project Period:
2000 - 2006

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Co-Investigator(s):
n/a

Abstract:
Many workers in the U.S. are potentially exposed to chemicals that can be absorbed through the skin and cause harm. However, NIOSH has few recommendations for identifying and controlling these situations. Consistent with the NORA Allergic and Irritant Dermatitis priority area, NIOSH established a research program to develop scientifically-based dermal policy based on laboratory and field studies. This Coordinating Core project provides a focal point for communication and coordination among program researchers and for communication with external partners and stakeholders. Outcomes have included progress in the internal research program, additional research on occupational dermal exposure issues at six institutions where pilot projects were funded, good response to the NIOSH Skin Topic Page and enthusiastic support for continuation of a conference series that focuses a multidisciplinary audience on prevention.

Impact:
Additional research on occupational dermal exposure issues is occurring at the institutions where pilot projects were funded: University of California at Los Angeles, Tulane University, Johns Hopkins University, Northwestern University, New York University and Yale University. The response to the NIOSH Skin Topic Page has been very good with the number of visits to the page per month averaging near 700 in 2003; OSHA put a link on their Web site. The conference held in 2002 has focused multi-national and multi-disciplinary efforts on common issues central to preventing harmful effects from exposures of skin to chemicals. The participants of the first conference enthusiastically supported the planning of a follow-on conference. The two known reviews of the first conference were positive: Potomac Section News: Newsletter of the Potomac Section of the American Industrial Hygiene Association (October 2002) and The Journal of the Royal Society for the Promotion of Health (December 2002).

Mechanisms of Arsenic Skin Diseases

Project Period:
1997 - 2000

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Co-Investigator(s):
n/a

Abstract:
Studies were designed to examine the cellular and molecular mechanisms associated with skin and bladder cancer as well as dermal toxicity (i.e., hyperkeratosis) from occupational and environmental exposure to arsenic. The studies employed primary human bladder and skin cell cultures, transgenic animal models and biopsies from humans chronically exposed to arsenic. Arsenic was found to selectively alter the gene expression of growth factors in urinary bladder tissue and skin tissue. Many alterations occur through the ability of arsenic to accumulate in epithelial cells of the bladder and skin and stimulate the MAP kinase pathway through activation of the EGF receptor. The toxicological effect of this response is chronic abnormal cell proliferation, an event important in

carcinogenecity. As epidemiological data have also indicated that arsenic can increase the risk of developing cardiovasacular disease, an animal model was also developed using APO/E mice.

Impact:
Results from these studies established that dysregulation of certain genes involved in cell growth, including transforming growth factor α (TGFα), play a role in arsenic hyperkeratoses and carcinogenicity in the skin and urinary bladder. Using this initial finding, the cellular events responsible for these changes, the doses at which they occur and the in vivo cellular targets were identified. Researchers at Columbia University, utilizing these findings, conducted epidemiological studies of arsenic-exposed individuals and demonstrated that urinary TGFα is a useful biomarker for arsenic exposure and early disease. This biomarker is now being employed in studies being conducted by the EPA and in several large epidemiology studies in China. Identifying early cellular molecular changes in the urinary bladder of mice exposed to arsenic in the drinking water allowed for conducting dose-response analyses.

Microscopic Analysis in Experimental Pathology

Project Period:
1996 - 2010

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Co-Investigator(s):
n/a

Abstract:
This project will provide and maintain facilities needed to visualize the impact of occupationally relevant particulates, vapors, and toxic chemicals on tissues, cells, and cell organelles. This project will use electron microscopes, laser scanning confocal microscopes, photomicroscopes, and image analysis programs to provide an imaging environment for production of high quality micrographs or data. Research will focus on preparation of tissues and samples for microscopic analysis, production of images at the light and electron microscope level, image analysis, and histopathologic evaluation of tissue samples. This project supplies essential data that are used to enhance research on emerging hazards and occupational disease mechanisms. Results will be useful in achieving the goals of these projects, which should allow the projects to impact risk assessment efforts.

Impact:
This project provides publication-quality micrographs, both at the light and the electron microscope levels, microscope slides for pathologic evaluation and scoring of disease severity, quantitative analysis of normal and experimental tissues, morphometric analysis at the light and electron microscope levels, and special histological and immunohistochemical staining to identify underlying causes of pathological conditions. In addition to basic microscopy services, this project explores new avenues for visualizing and analyzing cells, tissues, and other samples, and the project also provides leadership in using these avenues for occupational health investigations. This project has provided support for several studies which have directly impacted strategies for workplace prevention, such as the nylon flock study and the artificial butter flavoring study. In addition, this project has supported fiber studies used by IARC in evaluating the carcinogenicity of man-made mineral fibers and OSHA for evaluation of the silica standard.

Developing Healthy and Dermatitis Skin Absorption Models

Project Period:
2000 - 2005

Researcher Name:
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Jyoti Keswani, Ph.D.
NIOSH

Abstract:
A chemical's excessive contact with skin can lead to either systemic effects or an occupational skin disease, which is one of the leading causes of lost work days. NIOSH provides limited guidance in identifying and avoiding harmful skin exposures due to information gaps. This project attempted to fill some of the information gaps through laboratory studies of skin systems. This project started as a large effort that

was reduced in scope as experience was gained with a variety of skin models and their limitations in our hands. One of the results of this work is an improved analysis method for metabolites of the pesticide Alachlor. Preliminary results in skin decontamination studies have shown that even one washing with some cleansers can degrade the barrier properties of the skin detectably. Due to the low production rate of data of practical significance, this project is being terminated one year early.

Impact:
This project demonstrated the difficulty of starting laboratory studies of skin exposure but produced some useful information about methodologies. It will be terminated one year earlier than originally scheduled.

Mechanisms of Toxicity of Redox Reactive Intermediates in Skin

Project Period:
2001 - 2005

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Vincent Castranova, Ph.D.
NIOSH

Abstract:
The major focus of this proposal is to study effects of dermal exposures of two classes of chemicals (phenols and organic peroxides) causing a number of adverse effects in the workplace. Phenol compounds and organic peroxides are widely used in food and pharmaceutical industries and for production of phenol-formaldehyde resins, paints, varnishes, and laminating materials. The overall objective of this proposal is to study mechanisms of toxicity of redox reactive intermediates during enzymatic metabolism of phenols and organic hydroperoxides to elucidate the involvement of free radical pathways in cutaneous toxicity and skin disorders. With regard to phenolic compounds, the central hypothesis is that phenoxyl radicals, the primary one-electron oxidation intermediates of phenolic compounds and metabolites formed by oxidative enzymes, contribute significantly to their toxicity in skin. Phenoxyl radicals, by interacting with intracellular thiols, trigger redox-cycling cascades yielding different and new free radical species, thus inducing oxidative stress and damage.

Impact:
Phenols and organic peroxides are two groups of chemicals causing occupational health problems following exposure to skin. More than 600,000 workers are exposed to phenols. About 7 billion pounds of organic peroxides are consumed yearly in the US. Over 95% of cumene hydroperoxide is used for production of phenol and acetone. The data obtained from toxicological testing of adverse effects of phenolic compounds and organic peroxides to skin are vital to evaluate the health effects of these toxic substances and to determine levels of exposure that represent a significant risk to human health.

Mechanisms of Workplace-Related Irritant Contact Dermatitis

Project Period:
1997 - 2001

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Abstract:
Stress exacerbates dermal immunopathology, suggesting that workers experiencing emotional stress may have an exaggerated response to occupational chemicals. We have investigated the complex interplay between restraint stress and the development of allergic contact dermatitis (ACD) in the "stress sensitive" BALB/c mouse and the "stress resistant" C57BL/6 mouse. The timing of restraint, a murine stressor

analogous to emotional stress in humans, is critical in stress induced immunomodulation of ACD. Restraint applied to a chemically naive mouse depressed the cutaneous immune response to chemical, whereas restraint applied to a chemically sensitized mouse enhances development of ACD. Additional studies indicate that this dichotomous response is due, in part, to restraint modulation of Langerhans cell (LC) morphology and migration to the draining lymph node. These data demonstrate that stress modulates the cutaneous response to occupational chemicals and that the exposure status of the individual is important in determining the direction of the modulation.

Impact:
The National Occupational Research Agenda states that there is virtually no occupation without potential for exposure to agents that cause irritant (ICD) and allergic contact dermatitis (ACD). With new, potentially harmful chemicals being introduced into the workplace each year, an understanding of the mechanism through which chemicals induce irritant and allergic dermatitis will provide critical information necessary to develop appropriate exposure limits and improved strategies for prevention and treatment of disease. This study investigated the qualitative differences in the inflammatory response to irritant and sensitizing chemicals and advances our understanding of occupational chemical-induced contact dermatitis.

Develop and Demonstrate the Use of Colorimetric Indicators

Project Period:
2000 - 2006

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Co-Investigator(s):
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Abstract:
Colorimetric indicator pads will be created to provide a method to conduct field validation testing of chemical protective gloves and clothing to protect against skin exposure to aldehydes (formaldehyde and glutaraldehyde) and glycol ethers (2-butoxyethanol). The results of this research will be useful in allowing workers to determine when their protective gloves have been compromised so that they would be better able to protect themselves from chemical skin exposures.

Impact:
The results of the project will be submitted through referred technical journals for publication, will serve as the basis for further research with other chemicals, and will be used, in turn, to affect OSHA policy and standards. The use of colorimetric indicator pads in conjunction with existing dermal exposure prevention techniques should further reduce the number and severity of chemical dermal injuries.

• Asthma and Chronic Obstructive Pulmonary Disease •

Validation Studies in Occupational Immunotoxicology

Project Period:
1990 - 2005

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Abstract:
This project is a multi-year, multifaceted project, which is the result of an IAG between NIOSH and NIEHS, which began in 1991. The main purpose and direction of the project is to conduct field studies in worker populations where immunotoxic endpoints (immune suppression, hypersensitivity and autoimmunity) are suspected, and also to develop methods to further enhance our ability to diagnose immunotoxic diseases in workers. A second focus is to compare human disease endpoints to those in animal models. Field studies have been conducted in workers exposed to numerous agents including Stachybotrys chartarum, ethical narcotics, lead, egg proteins, and latex. Improved diagnostic tests have also been developed for vaccine efficacy and the detection of exposure to

bioterrorism agents. In collaboration with investigators from Health Effects Laboratory Division, NIOSH, animal model responses to latex have been compared to human responses.

Impact:
The overall allergenic potential of latex gloves is now evaluated by the measurement of Hev b5 and Hev b13 rather than by total latex protein measurements, based on the NIOSH identification of Hev b13 as a significant latex allergen. NIOSH is at present in a materials Cooperative Research and Development Agreement (CRADA) with National Center for Infectious Diseases (NCID) and Flow Applications, Inc. to develop a 23-PNPS assay. The fluorescent covalent microsphere immunoassay (FCMIAs) for the measurement of anthrax toxins, being more sensitive and able to measure three toxins simultaneously, is going to be used to re-measure the Capitol Hill anthrax sera and the 22 anthrax case sera from the anthrax attacks of 2001. NIOSH is presently re-testing latex allergic healthcare workers to determine the natural history of latex allergy in the absence of continued latex exposure.

Cough Sounds and Aerosols as a Predictor of Respiratory Disease

Project Period:
1997 - 2000

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Abstract:
The purpose of this research was to develop a new noninvasive method to detect lung disease in the worker population based on voluntary cough sound analysis. A prototype system was designed, constructed, and then tested in a clinical setting. The results have indicated that obstructive and restrictive lung diseases can be distinguished by characteristic alterations in the generation of a cough sound and its sound transmission path.

Impact:
The results of this research included two patents related to cough sound recording, analysis and playback. Private businesses have contacted the lab to discern more information about the research and to explore licensing potential. In addition the world's authority in lung acoustics, the International Lung Sounds Association, has added a symposium that deals with cough sound recordings to its annual conference. The project officer, Dave Frazer, has been asked to head this symposium, and the amount of research in this area has grown significantly since our initial presentations in this field of study.

Identification of Sub-populations Susceptible to Particle Exposures

Project Period:
2001 - 2001

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Abstract:
The goal of this project was to determine mechanism(s) by which particles, currently classified as nuisance dusts, may produce adverse health effects in chronic exposures. Exposure to nuisance dusts is widespread in industrial, construction, agricultural and mining settings. NIOSH specifically tested the hypothesis that lung injury results from a defect in clearance of apoptotic cells which are induced when lung burden to inhaled particles reaches a sufficient level.

Impact:
Our studies of lung collagenase activation by inhaled particles were used in addressing the potential for recovery from silica induced lung injury (Porter et. al, Toxicol. Sci, 79:370-380 2004). These data are being used by OSHA in the reevaluation of the silica standards. Studies of collagenase activation were used to demonstrate the toxicity of nylon shreds (Porter et al, J. Tox. and Environ. Health, 57:25-45) which subsequently led to remediation in the manufacturing processes sufficient to remove the inhalation hazard. Expertise gained

from studies of collagenase activation in alveoli and small airways was used to examine the extensive damage of airway epithelial linings in toxicity of artificial butter flavoring and thus has played a role in subsequent NIOSH recommended changes in manufacturing practice (Hubbs et al, Toxicol Appl Pharmacol. 185:128-35. 2002).

Particle Surface Area as a Dose Metric

Project Period:
2004 - 2008

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Abstract:
This project addresses two major issues. (1) Is particle surface area a more appropriated dose metric than mass when attempting to understand the toxicity of ultrafines? (2) Can in vitro models become more predictive of in vivo response with the use of a particle surface area per exposed cell surface area metric of exposure? The toxicity of ultrafine particles from welding fumes, diesel exhaust and combustion, and special purpose nanoparticles is of concern. These data will be used to model lung burden vs. response. Such identification of the proper metric for exposure would be invaluable to risk assessment for ultrafine particles.

Impact:
If surface area proves to be a more appropriate metric of exposure dose for ultrafine particles, this would greatly impact current industrial hygiene and risk assessment practice which monitors dose as mg/m3. The use of data from this project for modeling efforts by Education and Information Division, NIOSH and the Institute of Occupational Medicine may have a great impact on the relevance of in vitro and animal data to human risk assessment.

Nanotechnology Safety and Health Research Coordination

Project Period:
2004 - 2008

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Abstract:
This project will coordinate the activities of investigators in the Nanotechnology Safety and Health Research Program. The objectives of the Coordination Core project are: (1) to track progress of the 5 projects in the Nanotechnology Safety and Health Research Program; (2) to facilitate interaction and collaboration among program scientists; and (3) to disseminate information to the extramural occupational health community and foster partnerships. These objectives will be accomplished by quarterly envision meetings among project PIs, annual retreats of program scientists, and sponsorship of a scientific conference on nanoparticles in the workplace. Dissemination of results will be via the lay press, to industrial groups, and to other governmental agencies.

Impact:
The NIOSH Nanotechnology Safety and Health Research Program will address the following issues: (1) generation of aerosols of nanoparticles for toxicological evaluation, (2) characterization of generated nanoparticles, (3) evaluation of

the cardiopulmonary effects of exposure to single-walled carbon nanotubes, (4) evaluation of surface area vs. mass as a dose metric for exposure to nanoparticles, and (5) the effect of control devises on the generation of ultrafine particles by diesel engines. The Coordination Project will assist in fostering interaction between projects, identifying partners, and disseminating program results. This project should impact industrial, academic, and governmental partners.

Work-related Asthma in Offices and Schools

Project Period:
1999 - 2005

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Abstract:
The purpose of the proposed research is to collect information and to test hypotheses related to the identification and prevention of work-related asthma in office buildings and schools. Our principal aim is to identify risk factors for work-related asthma in buildings, in particular to quantify relationships between work-related asthma and indices of exposure, including moisture and bioaerosols. Specific aims are: (1) to undertake epidemiologic studies designed to investigate the relationship between building environmental factors and work-related asthma; (2) to develop and evaluate clinical and epidemiologic methods for case identification; (3) to develop and evaluate various industrial hygiene methodologies for the assessment of exposures and exposure surrogates potentially implicated in work-related asthma in buildings; and (4) to evaluate the efficacy of interventions in buildings with evidence of work-related asthma.

Impact:
Recommendations made in each building investigation resulted in remediation, often in the course of our continued study. Our findings regarding intervention effectiveness and biomass correlates are pertinent to gaps identified by the Institute of Medicine's subcommittee on damp indoor spaces and health, which published its summary of research and public health needs in late 2004. Our team had major impact on the field by participating in the planning of both Indoor Air 2002 (an international meeting) and the Surgeon General's Conference on Healthy Buildings in February 2005. Both of these efforts have mobilized diverse parties to continue public health work in this area. Our partnerships are continuing work begun in this project to further document what interventions are successful in one building and in bringing our approach with the semi-quantitative dampness index for use in public schools in Maine.

Metals: Asthma & Hard Metal Disease Models

Project Period:
1996 - 1999

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Cemented Carbide Producers Association

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NIOSH

Xianglin Shi, Ph.D.
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Abstract:
The objective of this project was to develop in vivo and in vitro models of metal-induced asthma and hard metal pulmonary disease and to characterize the effects of hard metal in the lung. Rats were administered, by intratracheal instillation, hard metal that had been sampled from a detonation coating site at which a worker had died from inhalation exposure. Treatment led to an increase in nitric oxide synthase, nitrotyrosine adduct formation and inflammation in the lung, and profound hyporeactivity to inhaled methacholine. In isolated airway smooth muscle preparations, hard metal cations elicited metal-specific effects on methacholine- and nerve-induced contractions. A live, face-to-face meeting between the Cemented Carbide Producers Association and NIOSH staff involved in the hard metal investigation was held early on to solicit input and comments from this industry organization.

Impact:
The hard metal industry is aware of the toxicity of this substance, and steps have been taken to reduce worker exposure. Ours was one of only a few studies to examine the pulmonary toxicity of hard metals, and the first to characterize the effects of hard metal on pulmonary function and reactivity in an animal model. Our papers have been cited in the research literature several times by others.

Occupational Asthma Disease Models

Project Period:
1996 - 2000

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Abstract:
The purpose of this project was to develop in vivo and in vitro animal models of occupational asthma, to understand the basis of the development of airway hyperreactivity in asthma, and to investigate the role of the airway epithelium in controlling airway reactivity in health and disease. Models of airway hyperreactivity were developed in several species and through the use of several treatments, including ovalbumin, ozone, and toluene diisocyanate. Reactivity measurements were made in vivo and in vitro, and the effects of agents on pulmonary function were assessed. It was discovered that the airway epithelium plays an important role in determining airway reactivity, that this role is affected in treated animals, and the modulation of airway reactivity involves the release of epithelium-derived relaxing factor. An international conference on occupational asthma was organized and held at NIOSH in Morgantown, WV to bring together leading experts to exchange scientific information.

Impact:
The International Conference on Occupational Asthma stimulated interest in the area as a research activity by investigators who had not previously been active in this area. The experiments we conducted produced significant advances into the understanding of the mechanisms of occupational asthma in general and airway hyperreactivity in particular. The publications of our findings have been repeatedly cited in the scientific literature and have influenced the research activities of other investigators.

Epithelial Transduction in Airway Hyperactivity

Project Period:
1999 - 2004

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Abstract:
This project developed new techniques for characterizing cellular transduction pathways, in particular kinase cascades and ion channels, in respiratory epithelium. These pathways are associated with the production and action of epithelium-derived relaxing factor. This report also evaluated changes occurring in animal models of occupational asthma. Epithelium-derived relaxing factor plays a role in the development of airway hyperreactivity in occupational asthma, because its release is altered in animal models of occupational asthma. Through the use of inhalation exposure of animals to asthmagens and irritants, cell culture of airway epithelial cells, measurement of bioelectric/ion channel events in epithelium, measurement of cell volume responses and characterization of related kinase pathways, we gained a great deal of understanding of the molecular mechanisms of action of inhaled asthmagens and the mechanisms by which the epithelium is involved in the etiology of airway hyperreactivity.

Impact:
Ours is the only laboratory in the world studying the role of epithelium-derived relaxing factor in the lung, and the transduction pathways related to its release and effects. The experiments we conducted produced significant advances into the understanding of the mechanisms of occupational asthma and popcorn workers' lungs in general and airway hyperreactivity in particular. The publications of our findings have been repeatedly cited in the scientific literature and have influenced the research approaches of other investigators.

Noninvasive Measures of Small Animal Response to Inhalation Exposure

Project Period:
2001 - 2004

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Abstract:
The purpose of this project was to develop non-invasive methods to measure the physiological response of small laboratory animals exposed to airborne toxins and workplace dusts known to cause asthma. Methods developed included: estimates of airway resistance, analysis of breathing pattern from the whole body plethysmograph, and analysis of cough sounds of small animals exposed to asthma-causing agents. The techniques developed and the information obtained from this project were implemented in many of the laboratory animal studies of possible airborne toxins encountered in the workplace. This project enhances the general research capability to address occupational health issues associated with the exposure of workers to airborne pathogens.

Impact:
The impact of this project has been an enhancement of the general research capability of the division to address occupational health issues associated with the exposure of workers to airborne pathogens. An array of noninvasive tests have been developed and implemented that allow pulmonary function measurements to be performed throughout an inhalation exposure study. These animals can then be passed on to collaborating researchers for various tests involving terminal procedures. This transfer results in a more efficient use of animals and technician time. The improvements in pulmonary function measurements developed during this project have enhanced the quality of the occupational health research being conducted.

Silica, Lung Cancer, and Respiratory Disease Quantitative Risk

Project Period:
1997 - 2006

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Abstract:
Potential occupational exposure to respirable crystalline silica (RCS) affects at least 1.7 million U.S. workers and thousands more worldwide. Exposure occurs in a wide variety of industries and occupations and is associated with silicosis, lung cancer, and other diseases. The purpose of this project is to conduct risk assessments that quantitatively evaluate the relationship between occupational RCS exposure and the risk of mortality or morbidity from silicosis or lung cancer. The risk assessments completed to date found that the predicted excess lifetime risks were 19/1000 for lung cancer mortality, 54/1000 for lung disease other than cancer (LDOC), and 75/1000 for radiographic silicosis in white male workers exposed for 45 years at the current OSHA standard for respirable cristobalite dust (about 0.05 mg/m3) (with 10-year exposure lag for lung cancer analyses and unlagged for LDOC and radiographic silicosis). These risks are in excess of what is usually considered acceptable by OSHA.

Impact:
The RCS quantitative risk assessments (QRAs) had international impact particularly in the areas of health policy and advancement of knowledge. Between 2001 and 2005, the RCS QRAs were cited in 17 articles in national and international journals, according to the Web of Science database. The QRAs were reported to the World Health Organization's (WHO) Task Force for global elimination of silicosis and are included in a 2003 WHO compendium of activities in occupational health. The lung cancer QRA was cited by the Health and Safety Executive (HSE) in an RCS hazard assessment document. HSE Hazard Assessment documents contribute to the development of health-related regulatory positions in the United Kingdom. The LDOC QRA was a key study used by the California Office of Environmental Health Hazard Assessment to establish a chronic inhalation reference exposure level for RCS (adopted in February 2005). OSHA will review the QRAs during its rulemaking process.

Workplace Exacerbation of Asthma

Project Period:
2000 - 2005

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Abstract:
This study is investigating the frequency, causes, and consequences of workplace exacerbation of asthma (WEA) to provide the information needed to plan effective preventive actions. The aims are to determine: (1) frequency of WEA, (2) circumstances at work associated with WEA. (3) social and economic costs associated with WEA, (4) Sensitivity and specificity of self-reported WEA. (5) Whether WEA predicts disease progression . The design is a prospective cohort study with a nested validation study. Responses to a baseline study questionnaire will be used to address aims 1-3. Also, patient records will be used to ascertain cost of asthma care (Aim 3). A subset of employed subjects will complete serial spirometry to determine the sensitivity and specificity of self-reported WEA (aim 4). All baseline participants will be asked to complete a follow-up questionnaire approximately two years later to investigate whether WEA at baseline predicts a worsening in asthma severity (Aim 5).

Impact:
First, the finding from the baseline survey that over one in five adults with asthma fulfill the criteria for workplace exacerbation of asthma draws attention to the magnitude of a problem that has gone largely unnoticed. Second, in order to implement the validation phase of this project, NIOSH project staff worked with the company that manufactures the portable spirometer to change the software for the device so that it collected data relevant to work-related asthma . The company (ndd Medical Technologies) now makes this software available to their customers at no additional cost . In other words, clinicians or researchers can use this off-the-shelf software to investigate work-related patterns in serial spirometry measurements.

Longitudinal Follow-up of Food Flavorings Exposed Workers

Project Period:
2001 - 2004

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Abstract:
NIOSH investigated a cluster of fixed obstructive lung disease resembling bronchiolitis obliterans in former workers of a microwave popcorn plant. Due to severe illness, several of these workers had been placed on lung transplant lists. The investigation identified an increased prevalence of fixed obstruction in current workers that was associated with inhalation exposure to butter flavorings. As a result, the plant implemented exposure controls based on NIOSH recommendations. Follow-up medical and environmental surveys at this plant show markedly decreased exposures and a decline in the proportion of the workforce with abnormalities or obstruction on lung function tests. NIOSH evaluations of five other microwave popcorn plants revealed a risk to flavoring-exposed workers throughout the industry. In plants where NIOSH identified risk, management enhanced exposure controls and added or improved respiratory protection programs for their exposed workers. Through this project, NIOSH investigators identified a new cause of a debilitating lung disease and stimulated broad preventive efforts.

Impact:
In plants where NIOSH identified risk, management enhanced exposure controls and added or improved respiratory protection programs. OSHA Region VII drafted safety guidelines for microwave popcorn companies. The Flavor and Extract Manufacturers Association reported working with member companies to minimize workers' exposures through the use of control technology. Some companies also revised their material safety data sheets for artificial butter flavoring. The Popcorn Board set up a committee to assure that all microwave popcorn packaging companies are aware of the exposure risks from flavorings, including ways to minimize this risk. This work also received extensive national media coverage. Several microwave popcorn companies are exploring ways to further control exposures through the use of closed processes. One company requested that NIOSH train their staff on how to set up a lung function testing program, including performing the tests using their own equipment. Another company requested NIOSH assistance in establishing an industrial hygiene monitoring program. This training was successful, and the companies were appreciative of the help NIOSH provided.

Identification of Occupational Allergens

Project Period:
1998 - 2006

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Abstract:
This project is intended to provide base support to address new problems or hazards identified by field investigators

(primarily the Health Hazard Evaluation program), to support projects with external collaborators (primarily endotoxin and allergic antibody determinations), and to evaluate new technologies. Exposure to substances that can cause hypersensitivity reactions are recognized as an occupational hazard, and are thought to play a role in some occupational lung diseases such as asthma and allergic alveolitis. This project is intended to address these concerns through the development of improved techniques for the detection of these immune reactions before adverse clinical outcomes occur, and through the development of improved techniques for the detection and identification of occupational allergens. The project involves the analyses of clinical samples, environmental bulk samples, and environmental aerosol samples. Successful completion of these investigations should lead to the development of effective prevention strategies for occupational allergies and asthma.

Impact:
The impact of the results obtained for multiple studies in this project are varied and far-reaching. Knowledge of the microbial contaminants in Metalworking Fluids (MWF) has led to workplace interventions and a reduction in HP from metal working fluids. Endotoxin assays were standardized resulting in better inter-laboratory comparisons and cross-study comparisons. Additionally, the endotoxin studies contributed to the development of an American Society for Testing Materials (ASTM) standard assay for analysis of endotoxin in metal working fluids. Other studies contributed to the fundamental knowledge basis for the effect of diesel exhaust particles and asphalt fumes on the immune system. Chemical detection and quantification methods for latex accelerators are currently being tested with potential to reduce accelerator levels in latex glove products.

Occupational Asthma: Inflammation and Workplace Diseases

Project Period:
1997 - 2006

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Abstract:
Our laboratory has developed a mouse model for occupational asthma that reflects workplace exposure conditions and concentrations. This has allowed determination of the exposure conditions involved in both the sensitization and challenge phases as well as elucidation of the immunological mechanisms responsible for the disease. Current efforts are focused on the use of transgenic animal models that will allow for identifying the role of oxidants and IL-1 in the early disease process. Additional studies are being conducted to identify the genetic polymorphisms in workers with occupational asthma that influence disease susceptibility. The ultimate goal of this latter study is to provide quantitative estimates of disease risk in the general population.

Impact:
Results from these studies can be used to establish a more accurate safe exposure level as well as identify the most relevant exposure determinants. The studies were specifically designed for application in risk assessment by employing relevant workplace exposure levels and exposure conditions. Understanding the mechanism of the associated response is also directly applicable to establishing safe exposure levels. For example, if immune mechanisms are responsible for asthma, then safe exposure levels need to address exposure conditions and concentrations which produce a challenge response. However, if the response is due to a Reactive Airways Dysfunction Syndrome (RADS) phenomenon, then higher, acute types of exposure need to be addressed.

Occupational Asthma Identification Methods

Project Period:
1989 - 1997

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Abstract:
The objectives of the study were to examine the potential of different health screening approaches among workers at risk of occupational asthma, and also to characterize the distribution and determinants of occupational asthma in various high risk industries, including workers exposed to diisocyanates. A total of 471 workers were enrolled in the project. Two years of follow-up were completed, including medical questionnaires, work histories, blood and serologic tests, serial peak flow and spirometry, skin tests, and in certain groups, methacholine challenges and nasal lavage. The project has resulted in data that improve the ability of NIOSH to recommend practical and effective secondary prevention of occupational asthma through medical screening programs based on serial or intermittent use of various screening measures. A number of workplace factors, including skin exposure to diisocyanates, were documented to increase the risk of development of asthma symptoms. The results of this project have improved science-based recommendations for prevention of occupational asthma.

Impact:
The results of the project have provided an important scientific basis for public health action and have been noted and discussed by occupational health professionals (Occupational and Environmental Medicine Report, American Thoracic Society International Scientific Conference). U.S. and international recommendations for health screening and other preventive activities in a broad range of workplaces have been based upon and referred to project findings (The British Occupational Health Research Foundation. Occupational Asthma: Identification, Management and Prevention: Evidence Based Review and Guidelines. 2004. International Consensus Report on: Isocyanates – Risk assessment and management. 2001. Bakke JV, ed.)

Uric Acid and Susceptibility to Ozone-Induced Lung Injury

Project Period:
2003 - 2005

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Abstract:
This project will study the antioxidant function of uric acid in the pulmonary system. The specific objectives are: (1) establish an animal model in which pulmonary uric acid concentrations are altered, (2) establish that pulmonary uric acid modulates susceptibility to ozone-induced pulmonary injury, (3) investigate the mechanisms through which uric acid may mitigate pulmonary inflammation and damage, and (4) determine if pulmonary uric acid contributes to the development of ozone tolerance. These studies will potentially impact our understanding of ozone-induced pulmonary diseases, such as edema and asthma. For example, these studies may establish if uric acid levels are a factor in determining susceptibility to oxidant-induced pulmonary disease, thus adding to our etiological understanding of individual susceptibility. Second, investigations of the pathophysiological mechanisms may aid in the development of therapeutic interventions.

Impact:
Potentially, results of the studies proposed in this project would impact our understanding of ozone-induced pulmonary disease in humans on several levels. First, these studies may help establish that uric acid levels are a factor in determining individual susceptibility to ozone-induced pulmonary disease, thus adding to our etiological understanding. Second, investigations of the underlying pathophysiological mechanisms will provide knowledge that may aid in the development of possible therapeutic interventions. Last, the results may be applicable to other occupational exposures, thus increasing the scope of the impact of this investigation to our understanding of occupational pulmonary disease susceptibility. However, based on the results to date, support for the hypothesis that pulmonary uric acid may be related to susceptibility to oxidant-induced lung injury is minimal. Thus the potential Research to Practice (R2P) impact is likely not to be as significant as initially projected.

Role of Adhesion Molecules in the Pathogenesis of Lung Disease

Project Period:
1996 - 1999

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Abstract:
The objective of these studies was to elucidate the role of adhesion molecules and lung surfactant in the pathogenesis of occupational lung diseases with the goal of preventing and treating these diseases in subjects at-risk, e.g. in occupations such as agriculture and the hard metal industry. The approaches are: (1) to study the basic mechanisms involved in regulating adhesion molecule expression in cell culture systems and to utilize the techniques developed to study the regulation of adhesion molecules in human peripheral blood leukocytes, and (2) to study the mechanisms by which lung surfactant inhibits nitric oxide production by alveolar macrophages. Ultimately the goal is to apply this knowledge to prevent or alleviate inflammatory processes, such as occupational asthma and other diseases induced by various occupational hazards including dust-induced and hard metal-induced lung disease.

Impact:
This project has contributed knowledge to basic mechanisms regulating inflammatory responses in the lung. This information may be useful in developing strategies to alleviate the inflammatory response to occupational exposures and thus decrease the incidence of lung diseases, such as chronic obstructive lung disease and asthma. The four papers resulting from this project have received a total of 84 citations in the 5 years since their publication.

Pulmonary Toxicity of Carbon Nanotube Particles

Project Period:
2004 - 2008

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Abstract:
Carbon nanotube (CNT) materials are among newly developed products and are currently of interest for a variety of applications. We hypothesize that the transition metal component of carbon nanotubes plays an important role in inducing pulmonary toxicity through induction of oxygen and carbon-centered radicals. The objective of this work is to evaluate the pulmonary toxicological effects of CNTs in vitro and in vivo. Four goals of the project are: (1) to study molecular mechanisms of CNT-induced cytotoxicity in human bronchial epithelial cells, human macrophages, and type II alveolar epithelial cells; (2) to determine the toxicity of intratracheally aspirated nanotubes in mice and the time course of recovery; (3) to develop a generation system for carbon nanotube aerosols for inhalation study; (4) To perform an inhalation toxicology study of aerosolized nanotube particles in mice. Results obtained from these studies will provide critical knowledge about the mechanisms of pulmonary toxicity of nanoscale materials.

Impact:
In the last four years, the federal government has provided over one billion dollars in nanotechnology research funding. CNT materials are among these newly developed products for a variety of applications in electronics, reinforced rods, micro-fabricating conjugated polymer activators, supersensitive sensors, enhanced electron/scanning microscopy, imaging techniques, and biosensors. Nanostructured or microstructured materials are valuable sources for bone substitutes, bio-mimetic composites, and chemical and genetic probes. Nanoengineered particles are already in consumer products, such as sun screens, cosmetics and toiletries, used daily by millions. The market for these materials is estimated to grow to over eight billion dollars in the next decade. Introduction of novel materials into industry requires evaluating safety and understanding the impact of nanomaterials on the environment, biological species and human health. To date, little information is available concerning the potential toxicity of nanotubes. Results obtained from these studies should provide critical knowledge about mechanisms of pulmonary toxicity of nanoscale materials.

Methods Development for Biomarkers of Exposure and Response to Low Molecular Weight Asthmatogens

Project Period:
1998 - 2002

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Abstract:
Low molecular weight chemicals may be haptens that bind to proteins and become allergenic/asthmagenic or aggravate/enhance asthma. The chemistry, and effects on immune parameters in animal models were examined for combustion particles, such as diesel exhaust. Diisocyanates, the most commonly reported cause of occupational asthma, were studied with respect to their reactions to thiols (to form bis-thiocarbamates), ability of the bis-thiocarbamates to react to proteins, and their potential toxicity.

Impact:
The results of this study advance the fundamental knowledge regarding potential diisocyanates interactions that may lead to disease. The results also suggest that diisocyanates toxicological/immunological effects may be mediated through bis-thiocarbamate intermediates. Alterations observed in both pulmonary inflammatory and immunological responses by combustion particles adds to the growing evidence of adverse health effects associated with these particles and in addition suggest that the effects on alveolar macrophages may be central to these perturbations.

Characterization of Experimental Trimilletic Anhydride Late-Phase Airway Response

Project Period:
2003 - 2006

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Abstract:
Trimilletic anhydride (TMA) is a cause of occupational asthma in workers exposed to this chemical. It is commonly used in the production of resins and plasticizers. An experimental model of TMA-asthma has been developed using the Brown Norway rat. Lung function is measured, non-invasively, following a short inhalation exposure to TMA aerosol. Drugs will be used to evaluate the similarity of the rat model to that of human TMA-asthma. The contribution of inflammatory cells, antibodies, cytokines and specific allergic mediators on the asthma-like responses seen in this rat model will be studied. A fully characterized model of occupational asthma could then be exploited to study potential biomarkers of disease and disease interventions.

Impact:
One of the objectives of this study is to ask how relevant this model is to that of human TMA– induced respiratory disease. Work done to date suggests that this model, phenotypically, resembles human TMA-asthma response immunologically, pathologically and physiologically. It remains possible that underlying mechanisms leading to this phenotypic expression may be different between species. TMA serves as a model representative of the class of organic acid anhydrides, but results may not be extrapolated to other low molecular weight occupational asthmogens. This study is one of several projects that have implicated the skin as a possible route of exposure leading to respiratory sensitization and specific airway reactivity. This implication is contrary to the current views that airway sensitization occurs only by way of airborne exposure and thus leads to a greater understanding of the potential routes of exposure causing asthmatic sensitization.

Role of Carbon NanoTubes (CNT) in Cardio-Pulmonary Inflammation & COPD-Related Diseases

Project Period:
2004 - 2008

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Abstract:
Nanoengineered particles are widely used in industry as well as in consumer products and, thus, have the potential for significant human exposure. To date little information is available on the toxicities of these materials. The exposure to low doses of these materials may not have direct pulmonary toxicity but may modify the progression of existing pathophysiological conditions related to chronic inflammation such as asthma, pulmonary obstructive diseases, or cardiovascular diseases. The unique physical characteristics (shape, size, surface area) and the metal constituents of these particles are major predictors for possible modifying effects on cardiopulmonary diseases.

Impact:
These studies will determine whether nanoparticles, and which types of nanoparticles, have the potential to influence lung diseases, including asthma, fibrosis, and Chronic Obstructive Pulmonary Disease (COPD) as well as coronary artery disease in exposed workers. Results from these studies should provide important information on hazard identification and dose-response which can be used in determining risk in the workplace.

Pathologic Responses to Agricultural Dust Exposures

Project Period:
1996 - 1999

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Abstract:
Agricultural workers are exposed to a variety of airborne pollutants and mineral dusts. This project explored whether mineral dust exposure leads to scarring in the lung, and if scarring occurred, what are the etiologic factors involved. To evaluate lung scarring caused by work exposure in farming, we obtained lung autopsy specimens on consecutive coroner's cases of Hispanic males with work exposure in farming. Lung dust burden, pulmonary fibrosis and lymph node fibrosis were prevalent in farmers compared to non-farm workers. These studies concluded that histopathologic changes in Central California farm workers were consistent with mineral dust-induced pneumoconiosis. To identify the etiologic factors involved in farm dust, we studied the airborne dust generated in grape and citrus harvesting fields using toxicity evaluations. These studies established that inorganic mineral fractions contained large concentrations of crystalline silica and silicate minerals and free iron which were contributing factors in cellular toxicity.

Impact:
The results of these studies were reported to CAL-EPA and are being used to evaluate ambient particulate standards.

Gene Environment Interaction in Occupational Disease

Project Period:
1997 - 2004

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Abstract:
This description is for the project that consists of the two sub-projects, Gene Environment Interaction in Occupational Disease and Biomarkers of Occupational Disease Risk. This research project investigates both environmental and genetic biomarkers of susceptibility. It is organized as a complementary molecular epidemiologic and basic science investigation. Populations of workers at elevated risk of cancer, asthma, silicosis, and chronic beryllium disease will be studied to evaluate the nature of gene-environment interactions. Normal human cells, with known genotypes, will be treated in vitro with potential etiologic agents. Their early responses to these exposures will be investigated. The goal of these studies is to monitor gene expression, and sentinel genes will be used to warn of potential adverse health effects before disease is clinically manifest. Several genes have been identified as biomarkers of polycyclic aromatic hydrocarbon exposure: these are CYP1B1, IL-1B and MMP1.

Impact:
Collaborators at the National Cancer Institute are using these data and further data cited in the publications listed to plan an intervention study in a human population in Linxian County, China.

• Cancer Research Methods •

Molecular mechanisms of UVB-induced carcinogenesis and prevention of UVB-induced diseases

Project Period:
2000 - 2005

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Abstract:
The researchers for this project conducted laboratory studies to understand the molecular mechanisms of UV-induced carcinogenesis and, to identify the role of reactive oxygen species (ROS), and to evaluate the effectiveness of antioxidants in prevention of UV-induced diseases. Thus far, the following results have been obtained: (1) UV induces phosphatidylinositol 3-kinase/Akt pathways through reactive oxygen species; (2) hydrogen peroxide plays a critical role in UV-induced signing and carcinogenesis; (3) apple peel extract inhibited UVB- or TPA-induced carcinogenesis in vitro and in vivo; (4) berry extracts, including blackberry, blueberry, and strawberry, inhibited growth and attachment of human lung cancer cells and blocked DNA damage induced by UV irradiation. These inhibitory effects appear to be mediated through ROS-AP-1-MAPKs signal transduction pathways; and (5) selected polyphenolic compounds from berries or other fruits were identified that possess strong antioxidant and anti-carcinogenesis effects, inhibiting ROS-AP-1-MAPKs pathways, inducing apoptosis, and inhibiting tumorgenesis and metastasis.

Impact:
The results obtained from the present study will improve our understanding of dermal toxicity and carcinogenesis induced by UV. The identification of novo chemoprevention and chemotherapeutic agents will benefit a broad range of the population. Such information will assist risk assessment efforts and prevention of skin damage.

Genetic Susceptibility to Occupationally-Induced Cancer

Project Period:
2003 - 2008

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Abstract:
Lung cancer is the leading cause of cancer death in the U.S. and is second only to bladder cancer in the number of cases linked to occupational exposure. Melanoma, another cancer with strong occupational links, currently has the fastest increasing incidence in men, and the increased incidence in women is second only to lung cancer. This continuing project will allow the localization, screening, and identification of genes that are involved in susceptibility and resistance to lung cancer and melanoma. Identification of these genes will allow identification of the "at risk" populations that are susceptible to the development of occupationally-related lung cancer and melanoma and may provide biomarkers for occupational exposure, the early detection and staging of lung cancer and melanoma, and molecular targets for therapeutic intervention into the disease process.

Impact:
The University of Arizona Cancer Center, Tucson, AZ, is planning a clinical trial of natural compounds and selected drugs that inhibit E2F1, a gene found to be amplified in melanoma by our analysis. A CRADA has also been established with Spectral Genomics, Houston, TX, for the development of comparative genomic hybridization arrays for the analysis of human lung cancer and melanoma.

Genetic Susceptibility to Prostate Cancer

Project Period:
1998 - 2001

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Key Partner(s):
n/a

Co-Investigator(s):
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Abstract:
Prostate cancer is the most frequently occurring male, non-skin cancer in America and other Western countries. African-American men have the highest rates of prostate cancer in the world, averaging about 1.5 – 1.7 fold greater than in Caucasians and 2 – 3 fold higher than in Asians. The development of prostate cancer is dependent on heredity, androgenic influences, and exposure to environmental or occupational agents. Genes that are involved in the metabolism of xenobiotic chemicals or androgen biosynthesis exist in polymorphic forms which exhibit altered enzymatic activities and have been shown to increase or decrease the risk of developing various forms of cancer. Polymorphic variants of the NAT2 (heterocyclic amine metabolism) and CYP17 (androgen biosynthesis) genes were analyzed to determine their potential contribution to the risk of developing prostate cancer.

Impact:
Our results indicate that the polymorphic alleles of either the NAT2 gene or the CYP17 gene do not convey increased risk of developing prostate cancer in either African-Americans or Caucasians.

Mapping of Lung Tumor Susceptibility Loci

Project Period:
1997 - 2000

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Co-Investigator(s):
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Abstract:
Lung cancer is ranked second only to bladder cancer in the proportion of cases thought to be due to occupational exposures. Melanoma, another cancer with strong occupational links, has the fastest increasing incidence in men, and the increased incidence in women is second only to lung cancer. Common genetic loci are involved in susceptibility to these cancers. Analysis of the sequential chromosomal changes which occur in the development of these malignancies will allow the identification of genes that are involved in the stepwise development of these cancers. Identification of susceptibility genes for melanoma and lung cancer development will allow identification of the susceptible populations that are at risk in the workplace and provide biomarkers for occupational exposure, early detection of disease, and targets for disease intervention.

Impact:
The finding that the same gene linkage groups are affected in development of both mouse lung adenocarcinoma and human lung adenocarcinoma demonstrated that the mouse lung cancer model is a valid experimental model for the study of the genetics of human lung adenocarcinoma development. The finding that mouse lung cancer susceptibility genes lie in chromosomal regions that are deleted or amplified during lung tumorigenesis suggests that lung cancer susceptibility genes exert their effects in a manner analogous to that of oncogenes, which accelerate tumor growth and are frequently amplified in tumors, and tumor suppressor genes, which suppress tumor growth and are frequently deleted in tumors. This was the first demonstration of a possible mechanism by which lung cancer susceptibility genes exert their effects. The detection of novel chromosome translocations in human melanoma cells provides further insight into the location of genes that are involved in the risk of melanoma development.

Molecular Mechanisms of Cadmium Carcinogenesis

Project Period:
2001 - 2004

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Abstract:
Large numbers of workers are at risk of developing cancer due to occupational exposure to toxic chemicals. The goal of this project is to identify and characterize genes that cause occupational chemical carcinogenesis. The knowledge about the genes causing occupational chemical carcinogenesis will be applied to develop biomarkers for occupational chemical carcinogenic risk and strategies to manage the occupational chemical carcinogenic risk. Genes differentially expressed in cells morphologically transformed by exposure to the occupational chemical carcinogen, cadmium, were identified and characterized in order to understand the mechanisms of occupational chemical carcinogenesis. Two genes: eukaryotic translation initiation factor 3 (eIF3) and eukaryotic translation elongation factor-1d (eEF-1d), were identified as novel cadmium-responsive proto-oncogenes. cDNA cloning and functional studies of the novel cadmium-responsive proto-oncogenes facilitated a better understanding of the molecular mechanisms responsible for occupational carcinogenesis due to exposure to cadmium.

Impact:
The expression profile of the novel cadmium-responsive proto-oncogenes are being validated using in vivo animal models and human tumor samples for their potential use as biomarkers for cancer caused by occupational exposure to cadmium. It is anticipated that the expression profile of the novel cadmium-responsive translation factors may be useful as biomarkers for the risk of developing cancer due to occupational exposure to cadmium. In addition, the novel cadmium-responsive proto-oncogenes may also be useful as potential targets for managing the risk for carcinogenesis due to occupational exposure to cadmium.

Chemical Sensitizers: Are they also Tumor Promoters

Project Period:
1999 - 2001

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Abstract:
The primary aim of this study is to determine if skin sensitizers from different industries with diverse chemical structures possess potential to be tumor promoters, if not frank carcinogens. The commonality between the sensitizers and tumor promoters is the induction of dermal inflammation. Some skin cancers in humans have been linked to occupational exposure to chemicals. These may be frank carcinogens, or skin sensitizers or both. The industries that use chemical sensitizers include, but not limited to, operations which produce epoxy resins, plastics, tanning materials and rubber as well as occupations like hair dressers, dentists, chemists, and agricultural workers. It is hoped that the elucidation of the role of skin sensitizers in tumor promotion will have implications for hazard identification and be employed in the development of prevention strategies.

Impact:
Skin cancer is by far the most common type of cancer,with a huge impact on morbidity, health, and healthcare economics. Organic peroxides have become a subject of occupational safety research interest due to possible genotoxic and carcinogenic risks in the workplace. Dermal exposure to Cum-OOH can cause a number of toxic outcomes in skin, e.g., allergic and irritant dermatitis, rash, defattening of dermis and hair loss, burns, and epidermal hyperplasia. We found that topical exposure to Cum-OOH induced time-dependent oxidative stress as well as papilloma and carcinoma formation in the skin of SENCAR mice during 20 weeks of a two-stage cancer-promotion study. The suppressive effects of aspirin and NS-398 (COX-2 inhibitors) observed in dermal cell cultures exposed to Cum-OOH suggest involvement of COX-2 in oxidative metabolism and possibly cancer promotion.

Mechanisms of Carcinogenesis Caused by Occupational Exposure to Metals

Project Period:
1999 - 2004

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NIOSH

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NIOSH

Abstract:
The goal of this project was to understand the mechanisms by which workers, occupationally exposed to metals and metal-containing particles, develop cancer. The hypothesis is that reactive metal intermediates and free radical reactions play an important role in the development of lung cancer in workers exposed to various metal fumes or dusts. In vitro and in vivo electron spin resonance, HPLC, and molecular biology techniques were employed (1) to develop biomarkers for early detection of oxidative stress and (2) to study metal-induced free radical generation, metal-mediated DNA alternations, expression of oncogenes and antioxidants, activation of nuclear transcription factors, cell growth regulation, apoptosis, and mutation. Results obtained may assist in the early detection of disease, the development of occupational exposure limits, and the implementation of prevention strategies.

Impact:
OSHA supported this project by funding an Interagency Agreement for the PI to evaluate mechanisms involved in chromium-induced carcinogenesis. The PI reported results annually to OSHA. These results were used for risk assessment to support standards-setting by OSHA for chromium.

Investigation of Occupational Diseases Caused by Metals

Project Period:
1996 - 1999

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Co-Investigator(s):
n/a

Abstract:
Certain transition metals, such as Cr and As, are well established human carcinogens. Investigation of the mechanisms of Cr and As toxicity and carcinogenicity is on the National Toxicology Program (NTP) priority list. Studies using acellular and cellular model systems indicated that these carcinogenic metals are able to generate reactive oxygen species. The overall hypothesis was that metal-mediated free radical reactions play a key role in the development of cancers in workers exposed to metal-containing particles. The long-term objective of this project was to elucidate the biochemical mechanism of metal-induced carcinogenesis. The specific aims were to evaluate: (1) mechanisms of metal-induced activation of oncogenes and certain nuclear transcription factors, such as NF-B and AP-1; (2) mechanisms of metal-induced apoptosis; (3) metal-induced p53 activation; (4) metal-induced cell growth regulation; and (5) mechanisms of metal-induced tumorigenesis in vivo. Electron spin resonance and state-of-the-art molecular biology techniques were used.

Impact:
The results obtained enhance our understanding of the mechanisms of metal carcinogenesis. The long-term goals are to provide a fundamental understanding concerning the mechanisms involved in the carcinogenic actions of metal compounds; to fill a need for the mechanistic information of cancer risk assessment for metal exposure; to propose methods for early detection; and to develop intervention and prevention strategies. OSHA considers that these results may assist in the early detection of disease, the development of occupational standards, and the implementation of secondary prevention strategies. Major results are expected to be published in reputable journals.

Silica Carcinogenicity: Use of Susceptible Mouse Models

Project Period:
2001 - 2007

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NIOSH

Abstract:
Epidemiologic and rat studies have reported an excess of lung cancer risk in certain silica-exposed worker populations, while in others the data have many uncertainties and have shown negative results. Because the data are very limited and controversial both in humans and animals, and due to the possibility of lung overburden in rat studies, we propose to undertake an experimental study using new animal models for assessing carcinogenesis. These studies are designed to provide a better understanding of the molecular mechanisms involved in carcinogenesis in a short time period. Proposed studies will use intratracheal instillation exposures in a variety of rodent strains, including knockouts, and monitor molecular and biochemical changes at stipulated time periods. Results of these studies will provide an integrated comprehensive understanding of mechanisms of carcinogenesis and may be used to evaluate human cancer risk.

Impact:
If crystalline silica is a potential carcinogen to humans, these studies may help in recommending new exposure levels in occupations where silica dust is fractured, ground, or pulverized by the use of mechanical tools. Workers involved in mining, drilling, pulverizing, tunneling and other occupations with silica will benefit from this study. Furthermore, such a study will unravel the molecular mechanisms involved in silica-induced carcinogenesis. This project will fill the gap in our knowledge on the mechanisms of silica-induced cancer, and data obtained should be useful to OSHA in their review of the silica standard.

Potential Occupational Etiology of Breast Cancer

Project Period:
2000 - 2003

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Co-Investigator(s):
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Abstract:
Agricultural chemicals have been implicated in breast cancer. This is a study of gene-environment interactions with respect to cell cycle control, agricultural exposures, and risk of breast cancer through the following: (1) In vitro studies using normal human cells to examine the immediate/early effects of occupational chemical exposures in relation to specific genotypes and will provide a basis to evaluate chemicals in current and future use; (2) Two breast cancer case-control studies that will evaluate the role of genetic polymorphisms in cell cycle control genes, occupational exposures, and their interaction. Measures of blood pesticides, DNA-adducts, and work exposures are being collected. An understanding of gene-environment interaction at a basic level will provide a broad base for development of strategies for breast cancer prevention that may benefit working women.

Impact:
These data could be used for the development of bioassays to assess the impact of pesticide exposures in population-based studies. This could be highly relevant in the case of malathion, which has been sprayed in recent years on large sections of the US population (New York City) in an effort to stop the spread of West Nile virus.

Biomarkers of Occupational Disease Risk

Project Period:
1997 - 2004

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n/a

Abstract:
This description is for the project that consists of the two sub-projects, Gene Environment Interaction in Occupational Disease and Biomarkers of Occupational Disease Risk. This research project investigates both environmental and genetic biomarkers of susceptibility. It is organized as a complementary molecular epidemiologic and basic science investigation. Populations of workers at elevated risk of cancer, asthma, silicosis, and chronic beryllium disease will be studied to evaluate the nature of gene-environment interactions. Normal human cells, with known genotypes, will be treated in vitro with potential etiologic agents. Their early responses to these exposures will be investigated. The goal of these studies is to monitor gene expression, and sentinel genes will be used to warn of potential adverse health effects before disease is clinically manifest. Several genes have been identified as biomarkers of polycyclic aromatic hydrocarbon exposure: these are CYP1B1, IL-1B and MMP1.

Impact:
Collaborators at the National Cancer Institute are using these data and further data cited in the publications listed to plan an intervention study in a human population in Linxian County, China.

• Control Technology and Personal Protective Equipment •

Controlling Isocyanate Exposures in Spray-on Bed-liner Applicators

Project Period:
2003 - 2005

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NIOSH

Ron Kovein
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Kathy Ernst/Bob Streicher
NIOSH

Abstract:
The purpose of this project was to conduct an exposure assessment of the spray-on truck bed-liner industry and develop recommendations and/or engineering controls to reduce methylene bis (phenyl isocyanate) (MDI) concentrations during the spray application of diisocyanate based elastomeric truck bed-liners. This project evaluated potential worker exposures to MDI during the spray application process by collecting MDI samples at six spray-on truck bed-liner facilities within the spray booths and adjacent areas. Results indicate that MDI concentrations within the spray enclosures at the six facilities ranged up to 5.4 mg/m3, some exceeding the NIOSH ceiling limit of 0.2 mg/m3 as a 10-minute ceiling concentration. Spray gun users wore supplied-air respirators, however, results show that ventilation must be improved to reduce MDI concentrations within the spray enclosure. In addition to a presentation at the 2004 American Industrial Hygiene Conference and Exposition, a NIOSH Alert has been prepared.

Impact:
The primary impact of this project is the development of a NIOSH Alert to inform the spray-on truck bed liner industry of the health hazards associated with MDI exposure during the spray application process; the need for the spray application process to be conducted within an enclosed area with exhaust ventilation to control and contain MDI aerosol; and the need for respiratory protection to prevent employee exposure during the process. The Alert will be distributed nationally to government, academia, bed liner industry representatives, and, most importantly, the individual bed liner shops. Additionally, the strong partnerships established with OSHA programs in the states of Washington, Colorado, and Michigan, as well as the leading spray-on truck bed liner companies and other industry leaders, continue to develop guidelines for designing spray enclosures and ventilation to reduce MDI concentrations within the spray enclosures to protect workers in this small business industry.

Reduce Injury & MSD Risk for Human-Machine Interaction

Project Period:
2002 - 2006

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Co-Investigator(s):
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NIOSH

August Kwitowski
NIOSH

John Bartels
NIOSH

Abstract:
The research will assess and reduce the presence of underground mine work hazards and work-related MSDs to which the work environment, equipment, and performance of work contribute significantly. Mine work hazards and work-related MSDs arise from improperly designed workstations, equipment, or work methods. Mine work hazards include machine and human-body appendage collisions and operator errors. Work-related musculoskeletal disorders include awkward postures, repetitive and forceful motions, and excessive jarring and jolting. This project targets underground extraction, bolting and haulage mining machinery workers, and includes (1) machine design parameters for boom swing speed, pinch points, and guidance on safe tram speeds; (2) development of tram and operating procedures for face equipment; and (3) improved seating and workstation design for haulage vehicles.

Impact:
Machine design parameters and/or modifications will be defined. Improved operating procedures will be developed to reduce injuries while operating face equipment. Results will empower mine safety personnel to better assess risk so that job tasks intended to reduce health and safety injuries can be evaluated and/or implemented more effectively.

Reducing Injuries from Jolting/Jarring on Mobile Equipment

Project Period:
2000 - 2003

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Co-Investigator(s):
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NIOSH

Abstract:
The research examined workers' risks from exposure to construction and agricultural machinery. The methodology used included human factors design considerations, computer modeling and simulation, collaboration with equipment manufacturers, and field and laboratory tests to validate engineering interventions. The primary equipment investigated by the Pittsburgh Research Lab (PRL) was farm tractors, while the Spokane Research Lab investigated construction equipment. Outcomes from the project recommended improvements to seat design, suspension system, maintenance and training to reduce back injuries and musculoskeletal disorders of the upper extremities from operating mobile equipment used in construction and agricultural industries.

Impact:
A major impact of this effort includes advancing the knowledge regarding farm equipment operator exposure to vehicle jarring/jolting and injury symptoms so that industry can take the results and apply them where necessary. The results of this study were shared with associations such as Pennsylvania State University (PSU) Farms, National Institute for Farm Safety (NIFS), American Society of Agricultural Engineers (ASAE), and equipment manufacturers. This project addressed health and safety issues related to human interaction with machinery. Research focused on minimizing the operator's chances of musculoskeletal disorders of the upper extremities and back injuries during mobile equipment operation.

Computational Fluid Dynamics (CFD) in Control Technology

Project Period:
1998 - 2006

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Abstract:
Computational Fluid Dynamics (CFD) is a powerful new tool, applied here to design effective control technology through the virtual prototyping process, in which many designs are evaluated prior to laboratory studies and workplace implementation. CFD resolves the fluid transport phenomena that determine the fate of airborne toxins in the occupational environment. It provides insight regarding exposure assessment and accuracy of measurement devices or simple exposure models. Division projects will continue to use CFD in parametric studies that evaluate the influence of variables on ventilation effectiveness. Laboratory and/or field studies will continue to be conducted to validate the CFD results. CFD will be applied to the control of exposure to silica, bioaerosols, and gas phase contaminants. Five journal articles or technical reports are expected to be published in the U.S. federal government fiscal year, 2005.

Impact:
CFD research conducted in the Engineering and Physical Hazards Branch has influenced several industries facing particularly challenging ventilation issues. For example, the CFD method of investigating pathogen transport first proposed by EPHB in 2000 has been adopted by the FAA's Center of Excellence for Airliner Cabin Environment Research

(COE-ACER), established in 2004. Within the COE-ACER, Boeing Commercial Airplanes' strategic planning includes working with government agencies (NIOSH included), academia and industry to enhance Boeing's competitiveness in aircraft cabin environment research. The NIOSH-Boeing collaborative study was reported in Fluent News, a trade journal. As another example, a draft journal article details recommended approaches for the difficult problem of controlling respirable crystalline silica emissions from the removal of mortar during building restoration. Members of the International Union of Bricklayers and Allied Craftworkers, along with companies that design and manufacture tuck-pointing tools, will benefit from this information.

Control of Exposures During Construction

Project Period:
1994 - 2004

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Federal Highway Administration (FHWA)

National Asphalt Pavement Association (NAPA)

Laborers' Health and Safety Fund of North America (LHSFNA)

Center To Protect Workers' Rights (CPWR)

United Labor Agency (ULA) of Cleveland, Ohio

Co-Investigator(s):
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Abstract:
Engineering measures for controlling occupational hazards in construction operations are inadequately utilized, and this project addressed construction processes which could benefit from application of engineering controls. Where controls are not commercially available, this project designed, and assisted in the design, of engineering hazard-reduction solutions. This project has applied engineering research towards drywall sanding, rebar tying, asphalt paving equipment, asphalt roofing kettles, abrasive blasting, and coal tar construction products. In addition, exposures to hexavalent chromium and crystalline silica, which occur in a variety of operations, were also focused on in this project. Widespread acceptance of engineering exposure-control measures for asphalt paving machines has resulted in reduction of asphalt-fume exposures to thousands of workers, and a similar outcome for drywall finishers was the goal of the effort in that sector.

Impact:
The engineering controls research for highway-class (greater than 16,000 pounds) asphalt paving equipment resulted in the development of a NIOSH publication, Engineering Control Guidelines for Hot Mix Asphalt Pavers, Part 1: New Highway-Class Pavers, a detailed document recommending engineering controls on all highway-class pavers manufactured after July 1, 1997. The guidelines introduced a novel certification procedure and minimum performance criteria for each manufacturer's engineering controls. This document was a collaborative development with EID, OSHA, and multiple external partners. In addition, the guidelines were the foundation for an OSHA Voluntary Agreement (signed January 1997) which promises to meet the implementation and certification recommendations of the NIOSH guidelines. The survey of drywall finishers and contractors has provided useful information that will be used in dissemination and outreach efforts to encourage wider use of the proven engineering controls. Further, the survey instruments themselves will be used as prototypes for future, similar efforts.

Laboratory Evaluation of Back Support Belts

Project Period:
1993 - 1998

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Co-Investigator(s):
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Abstract:
This project investigated the potential for back support devices to reduce various stresses to workers during controlled lifting activities. Different types of commercially available industrial back support belts, along with a no-belt condition were evaluated. Thirty workers were recruited for the study. The evaluation had two key components: (1) a biomechanics study and (2) a physiological study. Results from the biomechanics study indicate back supports do reduce upper body flexion and extension as well as torso velocity during a lift. The biomechanics study also revealed an increase in hip and knee flexion when wearing a belt. In contrast, the physiological study did not reveal a significant increase in key indicators such as heart rate, blood pressure, or respiratory frequency.

Impact:
Both laboratory studies used science-based performance criteria to evaluate potential benefits or harming effects of back belt usage. The physiological study identified only one significant variable out of five investigated. Of the 15 biomechanical variables studied, 6 of 15 (small box) and 8 of 15 (large box) were identified as having statistical significance when a back belt was introduced to the lifting task. However, from a practical sense, the changes in many of these variables did not represent any type of meaningful physical result. Thus, the laboratory studies have provided safety managers with the information they need to push for modifications to workplace design through the use of engineering controls or a change in manual handling tasks to reduce or prevent possible back injuries rather than relying on the use of back belts.

System Safety Concepts Applied to Personal Protective Equipment

Project Period:
2001 - 2005

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Co-Investigator(s):
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Abstract:
Currently, various emerging technologies are being investigated for improving the performance of personal protective equipment (PPE). A formalized process for addressing the safe application of this technology to PPE does not exist. This project will develop such a process for the functional safety of high tech PPE over the equipment's entire life cycle. A risk-based system safety process, along with lessons learned by other industries, is employed. The project's recommended safety process will benefit NIOSH internally by review of NIOSH-sponsored research and will benefit the global PPE community since no such system safety process specific to this technology formally exists.

Impact:
Members of the NFPA Technical Committee on Electronic Safety Equipment have agreed to participate in the development of these guidelines, and the NFPA has indicated that they may be used by the committee in the development of their standard. A First Responders Conference is being planned at Virginia Tech in October, 2005, where the "Recommendations" will be showcased and explained to all participants. All manufacturers of PPE that contain embedded electronics will be able to demonstrate the level of safety built into their products by following the process defined in the NIOSH "Best Practice Recommendations". Entities responsible for ensuring the safety of PPE equipment, such as NFPA, will be able to incorporate portions of the "Best Practice Recommendations" into their standards. NIOSH documents will be produced that contain the various parts of the "Guidelines for Advanced Personal Protective Systems for First Responders" and made available through normal NIOSH channels.

New Technology to Increase ROPS Use on Tractors

Project Period:
2000 - 2002

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Abstract:
Data from 1993 show that over 60% of tractors in use did not have Rollover Protective Structures (ROPS) installed. ROPS have been proven as an effective safety device to prevent fatalities due to tractor rollover. Approximately 75 to

180 people die each year due to tractor rollovers. The use of ROPS is almost universally recommended as the key factor in reducing the fatality rate due to tractor rollover. This project has developed engineering interventions designed to increase the use of ROPS, in an effort to meet the Healthy People 2010 goal to increase to 100 percent the proportion of agricultural production tractors fitted with rollover protective systems. Information has been shared with groups establishing ROPS certification standards such as the American Society of Agricultural Engineers (ASAE) and the Society of Automotive Engineers (SAE).

Impact:
The successful research efforts from this project have led to the initial development of cost effective ROPS designs applicable to older tractors. This work lead to the development of a follow-on project to commercialize the Cost-effective ROPS. In addition, the project team has developed and successfully tested an automatically deploying ROPS design suitable for newer tractors. This design is now in the final commercialization process with FEMCO and SCAG Equipment and should soon yield commercially available products for purchase on the Scag Zero-Turn Turf Tiger commercial lawn tractor. If these two products are fully adopted and implement on all tractors, old and new, in conjunction with a standard seat belt, they have the potential save, on average, 100+ lives annually.

Overhead Power Line Contact for Mobile Equipment

Project Period:
1999 - 2001

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Abstract:
A feasibility study at the Pittsburgh Research Laboratory during US fiscal year 1998 suggested that electrical injuries to vehicle operators and nearby support personnel could be significantly reduced merely by warning them when a vehicle had come into contact with an overhead power line. This project further examined that concept by evaluating two prototype devices. One device measured current flow from a power line through the equipment to ground; another measured the electric field between the equipment chassis and ground when the frame was energized by a power line contact. Full scale field tests measured the performance of each device. These tests proved conclusively that a simple, inexpensive, retrofitable electric field warning device was feasible and provided a reliable indication of power line contact. Implementation of such devices could cut in half electrocution deaths that occur when mobile mining equipment comes into contact with overhead power lines.

Impact:
The only known manufacturer of power line proximity warning alarms is HVP Systems, Inc., Sanford, FL. HVP added undercarriage electric field detection as an option to its existing product line of power line proximity warning devices. This resulted, in part, from a series of discussions with NIOSH engineers regarding the contact alarm concept.

Silica Dust Control in Metal/Nonmetal Surface Mining

Project Period:
1994 - 2000

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NIOSH

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Key Partner(s):
U.S. Silica Company

National Industrial Sand Association

Central Silica Company

Old Hickory Clay Company

Canada Centre for Mineral & Energy Technology

Co-Investigator(s):
n/a

Abstract:
Although the health hazards from silica dust have been well known and documented for many years, the problem of overexposure persisted for a number of job occupations in the surface metal/nonmetal mining industry. This research quantified silica dust sources throughout processing operations and demonstrated effective control technologies that can be implemented to reduce worker exposure to silica and other harmful contaminants.

Impact:
The total mill ventilation system has been adopted by the industry and is a common dust control technique in use at the vast majority of mineral processing operations today. It is believed that this is the most cost-effective technique that mineral processing operations can easily implement to lower respirable dust levels throughout their entire processing structure. The bag and belt cleaner device also proved to be a very successful research project. Packaging Systems International from Denver, Colorado and Venti Oelde, from Germany, are two companies that took this concept and expanded upon it into various commercially designed systems. In addition to these two techniques, all of the research performed in this research project was compiled into a mineral processing handbook. This document was very well received by the industry and hundreds of copies have been distributed.

Silica Dust Control in Metal/Nonmetal Mining

Project Period:
1997 - 2007

Researcher Name:
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NIOSH

Andrew Cecala
NIOSH

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Key Partner(s):
Unimin Corporation

Endless Mountain Stone Company

Tilden Iron Ore

United Steelworkers of America Union

National Stone, Sand and Gravel Association (NSSGA)

Industrial Minerals Association-North America (IMA-NA)

Co-Investigator(s):
n/a

Abstract:
Although the health hazards from silica dust have been documented for many years, the problem of overexposure still persists for a number of job occupations in both underground and surface metal/nonmetal mining operations. Several occupations have been identified as being chronically exposed to excessive quantities of dust. Dust surveys will be conducted at underground limestone mines, surface silica sand operations, a dimension stone shop, and an iron ore plant to identify sources of dust generation and exposure for high risk occupations. Research will be performed to develop and evaluate control technologies that can be implemented to reduce the exposure of these workers to excessive levels of silica dust.

Impact:
A "Minerals Dust Control Handbook" was assembled to summarize numerous research findings. The handbook was uploaded by the Occupational Safety and Health Administration onto their Web site to facilitate use by industry. A video tape was produced that details results and gives recommendations for retrofitted air pressurization and filtration systems on enclosed cabs. This video is available on the NIOSH web site. A "How To" video was produced on the construction and operation of the clothes cleaning booth, which is also available on the NIOSH Web site. Since the clothes cleaning process is not currently approved for use in the mining industry by MSHA, Unimin Corporation has submitted a "Petition for Modification" to use this method at their production facilities. Several underground limestone mines have implemented directed ventilation systems to improve dust dilution and removal from these large opening mines.

Assessing Respirator Fit to Improve Protection against TB

Project Period:
2000 - 2003

Researcher Name:
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NIOSH

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Key Partner(s):
Warren R. Myers, Ph.D., CIH
West Virginia University

Co-Investigator(s):
Ziqing Zhuang, PhD.
NIOSH

Donald L. Campbell, PhD.
NIOSH

Robert B. Lawrence
NIOSH

Abstract:
This primary prevention study evaluated the simulated workplace performance [i.e., 5th-percentile of the simulated workplace protection factor(SWPF)] of six surgical masks and 30 (15 elastomeric and 15 filtering facepiece) N95 respirators with and without qualitative and quantitative fit-testing, the error rates associated with the three fit-test methods, and the effect of passing a fit test on respirator performance. The 5th percentile SWPF was measured on a panel of 25 people with varying-sized faces using a TSI PORTACOUNT Plus model 8020. The fit-testing results were compared to the 5th percentiles SWPF values. Alpha errors (the chance of failing a fit-test in error) ranged from 40% to 71%. Beta errors (the chance of passing a fit-test in error) were approximately 8%.

It was found that passing a fit test generally improves the protection afforded the wearer. The data supports fit testing as an essential element of a complete respiratory protection program.

Impact:
Given that fit-testing is an essential and critical element of respiratory protection programs, the excessive errors of the three fit-test methods used in the current study can inadvertently lead to less reduction in exposure than expected from the respirator class for respirator wearers. If an employee has three trials to pass a fit-test, the probability that a worker would mistakenly pass a fit-test with an inadequate-fitting respirator, could be as high as 1 in 5. Fit-test method errors may be sensitive to the characteristics of the respirator models used to assess those errors, and therefore, that fit-test accuracy may vary from one respirator model to another. This project provides a stimulus for further study to answer why different types of respirators provide different fit-test method errors, to develop a method with lower α and β errors, and to obtain estimates of fit-test errors in the context of respiratory protection programs.

Life Support for Survival and Rescue

Project Period:
1992 - 2006

Researcher Name:
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NIOSH

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Key Partner(s):
MSHA
UMWA
NFPA

Co-Investigator(s):
Nicholas Kyriazi
NIOSH
Tim Rehak
NIOSH
John Shubilla
NIOSH

Abstract:
After an underground mine fire or explosion, the mine atmosphere may become oxygen deficient or filled with smoke and toxic gases. Respiratory protection is necessary for successful escape from the mine and for mine rescue and recovery activities. Only closed-circuit breathing apparatus (CCBA) provide the capacity necessary for these activities. This project focuses on improvements in the design, reliability, and testing of closed-circuit breathing apparatus. For long-Term Field Evaluation: 200 self-contained, self-rescuers (SCSRs - CCBA used for escape) and 70 filter self-rescuers deployed in underground coal mines are collected each year and tested in order to assure their proper functioning in the event of emergency use. CCBA certification tests and standards need revision in order to improve apparatus safety and reliability.

Impact:
Smaller and lighter SCSRs, developed through government contract, have enabled more miners to wear the units rather than store them at some distance away, giving them immediate access to respiratory protection.

Engineering Controls for Hearing Loss Prevention

Project Period:
1999 - 2004

Researcher Name:
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NIOSH

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Key Partner(s):
United Mine Workers of America (UMWA)
Bituminous Coal Operators' Association (BCOA)
National Mining Association (NMA)
Mine Safety and Health Administration (MSHA)
JOY MINING MACHINERY

Co-Investigator(s):
Paul Jurovcik
NIOSH

Abstract:
After an underground mine fire or explosion, the mine atmosphere may become oxygen deficient or filled with smoke and toxic gases. Respiratory protection is necessary for successful escape from the mine and for mine rescue and recovery activities. Only closed-circuit breathing apparatus (CCBA) provide the capacity necessary for these activities. This project focuses on improvements in the design, reliability, and testing of closed-circuit breathing apparatus. For long-Term Field Evaluation: 200 self-contained, self-rescuers (SCSRs - CCBA used for escape) and 70 filter self-rescuers deployed in underground coal mines are collected each year and tested in order to assure their proper functioning in the event of emergency use. CCBA certification tests and standards need revision in order to improve apparatus safety and reliability.

Impact:
The Noise Partnership, comprising the UMWA, BCOA, MSHA, NMA, and coal mining companies, fully adapted the coated flights and mist system. This effort will impact a

decrease in the noise exposure of continuous miner and roof bolter operators, using a simple and cost effective control method. Both controls are currently being marketed commercially by JOY Mining Machinery, who has over 80% of the continuous mining machine market.

New Models for End-of-Service-Life Prediction and Changeout Schedules

Project Period:
2001 - 2007

Researcher Name:
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Key Partner(s):
LANL
OSHA
The International Safety Equipment Association
The American Chemistry Council
The Synthetic Organic Chemical Manufacturers Association
The National Paint and Coatings Association
The American Petroleum Institute
ORC Worldwide

Co-Investigator(s):
Dr. Gerry Wood
Los Alamos National Laboratory

Abstract:
In 1998, the Occupational Safety and Health Administration (OSHA) promulgated revised respiratory protection standards which changed the way in which chemical cartridges for respirators were selected and used. Under the new OSHA regulations, either an end-of-service-life (ESLI) indicator or a changeout schedule is required to determine when cartridges need to be replaced. Formerly, odor detection was permitted. Due to great variations in the ability of different people to detect odors of gases and/or vapors, odor detection has been found to be unreliable. ESLI availability is very limited, and there are no ESLI indicators for organic vapors. There are mathematical models that can be used to determine changeout schedules, but they are very general and they do not address the effects of humidity or multiple organic vapors on the usefulness of the cartridges. This project developed, analyzed, tested, and disseminated mathematical models and supporting information regarding changeout schedules for use with air-purifying respirators.

Impact:
In 2004 a model was released to OSHA and the public. It determined service life for a single organic vapor with relative humidity effects. OSHA placed it on their Web site and over 1700 downloads occurred during 2004. Over three thousand visits were made to the Web site to view the training video or ask questions. Five hundred CDs of the modeling and training video were distributed by NIOSH.

Characterization & Mitigation of Mine Gas Emissions

Project Period:
1996 - 2001

Researcher Name:
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NIOSH

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Key Partner(s):
Cyprus Emerald Resources
Island Creek Coal Co. (now part of Consol Energy, Inc.)

Co-Investigator(s):
Stephen J. Schatzel
NIOSH
Fred Garcia
NIOSH
James P. Ulery
NIOSH

Abstract:
The objective of the project was to develop optimized longwall methane control systems and strategies to reduce the risk of explosions and fires in the underground workplace. The mining industry's continual implementation of advanced mining technologies to increase coal production sometimes results in unexpected consequences, including increased methane emissions. Methane control technologies currently in use were developed in the 1970's, and in many instances they have evolved slowly by trial and error methods. However, these trial and error based improvements in control technologies have not kept pace with the rapid development of high production mining systems in use on today's large dimension longwall panels. This research effort identified the key geotechnical and mine design variables influencing the release and migration of methane on large dimension longwall panels necessary to develop optimized methane control strategies.

Impact:
The fundamental knowledge of the behavior of methane in the longwall mining environment has been the basis for optimized methane drainage recommendations and best practices that have been made available to the mining industry. Mine operators can now design optimized gob gas ventholes to remove a larger volume of gob gas that would have otherwise entered the underground workplace. The method developed

to estimate the methane emission consequences of mining a wider longwall panel and the commercialization of the Portable Modified Direct Method Testing Apparatus provides mine operators with better tools to determine if increased ventilation capacity or additional methane drainage will be needed on a site specific basis to address forecasted increases in methane emissions. Taken as whole, this research effort has provided the mining industry with the tools necessary to reduce longwall methane emissions, thus reducing worker exposure to the risk of an explosion in the underground workplace.

Degradation and Decon Efficacy of Chemical Protective Clothing

Project Period:
2001 - 2006

Researcher Name:
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NIOSH

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Key Partner(s):
Beth Tomasovic
Crystalview Technology Corp
Bill King, Ph.D.
Crystalview Technology Corp
Gang Sun, Ph.D.
University of California, Davis

Co-Investigator(s):
n/a

Abstract:
The overall goal of this project is to reduce occupational skin diseases and skin injuries resulting from secondary exposure to contaminated chemical protective clothing (CPC) and gloves. The specific aims are: (1) to develop suitable methods and procedures for decontaminating and extending useful life of chemical protective clothing, (2) to develop test methods for evaluating decontamination efficacy, and (3) to provide a guideline for retirement and disposal of chemical protective clothing.

Impact:
The results have been incorporated into a CPC decontamination guideline co-developed by NIOSH and AIHA. The health of American workers that rely on the CPC will be improved. The research outputs will have an impact on ASTM, OSHA, and NFPA when developing new standards or regulations. The Permeation Calculator has the potential to be adopted nationwide as a means for standardizing the data analysis for permeation testing. This will benefit workers in academia and industry, professors, and college students involved in education or research with respect to the CPC field, and CPC manufacturers. An Employee Invention Report for the computer program has been submitted to CDC Technology Transfer Office for patent application. The self-decontamination study won a Director's Award at the 12th National Textile Center's annual forum in February 2004. Dr. Gang Sun at UC, Davis has planned to integrate the innovative technologies into firefighter ensembles for biological/chemical protections.

Control of Silica Dust Exposure in Underground Coal Mining

Project Period:
1997 - 2002

Researcher Name:
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NIOSH

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Key Partner(s):
Mine Safety and Health Administration
United Mine Workers of America
Mon-View Mining, Monongahela, PA

Co-Investigator(s):
Jay F. Colinet
NIOSH
Steve Schatzel
NIOSH

Abstract:
Exposure data gathered from MSHA field offices showed that excessive occupational exposures to respirable silica dust continued for roof bolter and continuous miner operators in underground coal mining. These overexposures presented unacceptable health risks. To control silica exposures at roof bolting occupations, a canopy air curtain and smaller air tube were developed and evaluated. Mounted on the underside of the driller's canopy, each of these devices provided a downward flow of filtered air over the breathing zone of the bolter operator. Improved methods for cleaning the roof bolter dust collector box were also investigated and identified. For continuous miners, full scale laboratory tests assessed various external spray system designs for their effectiveness in controlling both respirable dust and face methane concentrations. Operating conditions that maximized control of dust and gas were developed. In-mine samples were also collected to characterize the rock surrounding the coal seam and associated silica liberation.

Impact:
As a result of this lab work, it became evident that silica dust exposures for the bolter operator could be reduced best by

using the canopy air curtain as opposed to the air tube. This led to an evaluation at an underground mine operation. In-mine testing of the reusable brattice bag showed that its use could control silica dust exposures. After testing, the mine continued to use the bag. Laboratory and field testing by NIOSH showed that blocking sprays placed near the hinge point improved control of respirable dust by increasing its capture by the dust scrubber. Such blocking or chassis sprays are now offered on new continuous mining machinery as part of an OEM spray configuration. These sprays generally are placed closer to the scrubber, as dictated by our results.

Silica Dust Control in Underground Coal Mining

Project Period:
2002 - 2007

Researcher Name:
Gerrit Goodman
NIOSH

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Key Partner(s):
Black Beauty Coal Company, Vincennes, IN

Performance Coal Company, Naoma, WV

Peabody Coal Company, Marion, IL

Mine Safety & Health Administration

United Mine Workers of America

Co-Investigator(s):
Steve Schatzel
NIOSH

Douglas Pollock
NIOSH

Tim Beck
NIOSH

Abstract:
This project will develop technologies to limit exposures to respirable silica dust for operators of roof bolters and continuous mining machines. To control exposures for roof bolters, an in-mine evaluation of a canopy air curtain is planned, as well as an assessment of methods for cleaning the canister filters present in many vacuum dust collection systems. For continuous miner operators, this work will evaluate the impacts of ventilation parameters on the control of both respirable dust and face gas levels. Also, this project will assess new inlet designs to improve the capture of respirable dust with a flooded-bed dust scrubber. Research will be completed to investigate the relationship between silica in the coal mine strata and the silica that becomes airborne.

Impact:
Evaluation of the canopy air curtain showed that dust levels were lower when working beneath this device, indicating increased protection for the mine worker. At the present, the air curtain is one of a few technologies available to control roof bolter exposures when working downwind of the continuous mining machine. As a result of these efforts, the bolter manufacturer wants to coordinate efforts with NIOSH to improve the design of this device for future commercialization.

Improving Ventilation Technology in Large Opening Mines

Project Period:
2000 - 2005

Researcher Name:
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Key Partner(s):
Frank Mazurek
Coolspring Stone Supply Inc.

Trent Spendrup
Spendrup Fan Co

Ron Werry
Hansen Aggregates Inc.

Ron Vanick
Coolspring Stone Supply Inc.

Co-Investigator(s):
Robert Krog
NIOSH

Susan Robertson
NIOSH

Abstract:
This project is enhancing the science of improving ventilation in large, low-velocity mine airways. A computer software program the "Air Quantity Estimator" was developed to determine the necessary air quantity to dilute diesel particulate matter. Using this program and through observation and ventilation surveys, it was determined that the required air quantity through many large opening mines was best achieved by using propeller fans. Through case studies, it was shown that propeller fans perform well in large opening drift mines because large air quantities are delivered at small static pressures. Two mine ventilation concepts: perimeter and split unit mine ventilation were developed in conjunction with the fans to deliver and direct the required air throughout the mine. In addition, the researchers developed improved stopping construction methods and identified flexible materials used for stoppings. This resulted in the development of two novel stoppings: the "Easy-Up Stopping" and the "Super Stopping".

Impact:
An operator used the Air Quantity Estimator to identify two vehicles that accounted for 25% of the DPM emissions from the entire underground vehicle fleet. Several mine operators have exchanged diesel engines based on insight that the program provided. At a recent workshop, the Air Quantity Estimator software program was requested by over 25 individuals working in the stone industry.

Engineering Controls for Metalworking Fluids

Project Period:
1997 - 2001

Researcher Name:
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NIOSH

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Key Partner(s):
OSHA
Cincinnati Milicron
University of North Carolina
Ford Motor Company
General Motors Coporation

Co-Investigator(s):
Gary S. Earnest
NIOSH
Daniel S. Watkins
NIOSH

Abstract:
The goal of this study is to identify and measure the effectiveness of control measures for metalworking fluids (MWFs). This project will evaluate the technical and economic feasibility of retrofitting controls to existing machining operations involving MWFs. MWFs encompass a broad class of mineral oils, water soluble oils, and chemical solutions that cool, lubricate, and cleanse in metalworking operations. Exposure to MWF mist has been associated with an increased incidence of occupational cancer, and respiratory and dermatological diseases. The incidence of these health effects can be reduced by enclosure of the operation, local and general ventilation, management of the fluid and its delivery system in a sanitary condition, and chemical treatments to retard mist generation and microbial growth.

Impact:
The results of this project have impacted the machining industry in a number of ways. The filtration work has highlighted the effectiveness of mist collectors used in the industry and demonstrated that some collectors can be more effective than others. Selection of the proper collector will have an impact on the workers' exposures. For the microlubrication work, the significant impact will be on the prevention of future exposures. Through this work, the machining industry has been shown that switching to this method of fluid application can have a detrimental effect on exposures, if the proper measures are not taken. By providing mist collection equipment with the advantages of microlubrication, workers in the machining industry can be better protected from a variety of health hazards.

Surface Blasting Safety and Health

Project Period:
2001 - 2005

Researcher Name:
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NIOSH

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Key Partner(s):
Mine Safety and Health Administration

Co-Investigator(s):
n/a

Abstract:
Since 1988 there have been eleven (11) incidents in which it is suspected that blast-generated CO migrated through the ground, resulting in CO poisoning. In ten of these cases, the blasting was part of a construction project or at a strip mine. In all, twenty-three (23) people were hospitalized and treated for CO poisoning, with one fatality. Blasters need to know how to protect against CO poisoning. Every blast is associated with fragmentation and often the projection of rocks. Flyrock and blast area security dominate blasting-related accidents in surface mining. The objectives of this task are: (1) determine the causes of flyrock related fatalities in the construction industry during the past decade, (2) publish the results of the mining and construction industry studies, and (3) work with MSHA to produce and distribute flyrock awareness materials.

Impact:
Many blasters now install CO monitors in homes and other confined spaces near a blast site. Residents and workers are told the reason for having the monitors and are told what to do if they alarm. There have been no recent cases of CO poisoning resulting from the migration of CO from the blast site. Today, cases of CO migration are identified by the alarming CO monitor rather than people becoming ill. At one time, blasters had hoped to be able to know if CO migration was going to be a problem for a given blasting site. They now realize that the geology involved is too complex to permit predictions using currently available technology and are relying on public education and CO monitors instead.

Commercialization of a Cost-effective ROPS (CROPS) Design

Project Period:
2003 - 2004

Researcher Name:
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NIOSH

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Key Partner(s):
FEMCO, Inc.
ROPS manufacturer

High Plains Intermountain
Center for NIOSH Agricultural Safety

Agricultural Health and Safety and Health Center

Co-Investigator(s):
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NIOSH

John Etherton, Ph.D
NIOSH

Tony McKenzie, Ph.D
NIOSH

Mahmood Ronaghi
NIOSH

Abstract:
Over 100 farmers die each year in the United States due to tractor overturn. Rollover protective structures (ROPS) for tractors are extremely effective in preventing these fatalities when used with a seatbelt. The long-term goal of this project is to increase the portion of tractors in the United States which have a ROPS and seatbelt installed. To accomplish this, NIOSH worked with a ROPS manufacturer to develop cost-effective ROPS (CROPS) designs for five common tractor makes/models. Millions of tractors in the United States do not have ROPS, and cost can be an important factor when farmers consider placing ROPS on their tractors. Prototype designs developed by NIOSH are estimated to cost less than half the installed cost of a typical commercial ROPS. As a result of this project, farmers will have additional, lower cost options for fitting a ROPS to their tractor.

Impact:
CROPS designs have been developed for five tractor models which account for over 250,000 of the non-ROPS tractors in the U.S. Since various tractor models can have substantially the same design, many additional tractors could be accommodated. CROPS work is recognized in the NIOSH Agricultural Safety and Health Centers National Agricultural Tractor Safety Initiative, and additional research in this area is recommended. By establishing a Letter of Agreement with a ROPS manufacturer, this project has moved the idea of a more affordable ROPS closer to commercial reality. ROPS usage in the U.S. increased from 38% to 50% between 1993 and 2001, but most of this change can be attributed to attrition of older non-ROPS tractors and replacement with newer, ROPS-equipped tractors. At this rate, it will take an additional 15 years to reach 75% ROPS usage. Low-cost, easily assembled ROPS options should accelerate the rate of ROPS adoption.

Surface Mine Dust Control

Project Period:
2003 - 2008

Researcher Name:
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NIOSH

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Key Partner(s):
Clean Air Filter (Filter Manufacturer)

Shafer Brothers Construction (Surface Coal Mine)

Co-Investigator(s):
John Organiscak
NIOSH

Steven Page
NIOSH

W Randolph Reed
NIOSH

Abstract:
MSHA dust exposure data show that the highwall drill operator is the occupation at surface coal mines that most frequently exceeds the permissible exposure limit (PEL) for respirable silica dust. NIOSH field studies have shown that many surface drills have dust containment and capture problems at the shrouded drill table above the hole. Laboratory and mine-site development work for improving the highwall drill's primary dust collection system will be conducted, as well as investigations into improving quality control methods to ensure the integrity of enclosed environmental cabs. Additional efforts will focus on the interactions between drilling parameters and overburden lithology and how this interaction affects respirable dust generation, wet drilling technology, dust emissions at the drill's collector dump point and haul truck dust. This research will identify effective control technologies for surface coal mining operations to reduce the respirable silica dust exposure for mine workers.

Impact:
To date, mine site surveys have evaluated several different methods to reduce dust levels at surface mines and the information has been reported in the literature. At this time, impact has not been determined with project completion scheduled for 2008.

Dust Control in Surface Coal Mining

Project Period:
1997 - 2003

Researcher Name:
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NIOSH

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Key Partner(s):
Clean Air Filter (Filter Manufacturer)
Shafer Brother's Construction (Surface Coal Mine)
T&T Coal Company (Surface Coal Mine)
Leslie Resources (Surface Coal Mine)

Co-Investigator(s):
John Organiscak
NIOSH
Steven Page
NIOSH

Abstract:
The purpose of this research was to identify the effectiveness of dust control technologies used for highwall rock drills and bulldozers at surface coal mining operations and to improve coal miners' health protection from silica dust exposure through advancement of existing control technologies. Mine Safety and Health Administration (MSHA) dust exposure data showed that highwall drill operator and bulldozer operator were the occupations at surface coal mines that most frequently exceeded the Permissible Exposure Limit (PEL) for respirable dust. NIOSH field studies showed that the rock drill was the largest and most variable dust source. Many of the drills surveyed had dust containment and capture problems at the shrouded drill table above the hole. Laboratory and mine-site development work for improving the highwall drill's primary dust collection system was conducted, as well as, investigations into improving quality control methods to ensure the integrity of enclosed environmental cabs.

Impact:
NIOSH's results showing the Rotoclone collector to be a poor control technology led to MSHA banning this type of collector for use in surface coal mining operations. However, the improvements that NIOSH made in the performance of the Rotoclone collector could be used to reduce dust levels for these collectors that are used on construction equipment. NIOSH developed a number of operational guidelines for improving the dust levels found in enclosed cabs on surface mining equipment and incorporated this information into a video. NIOSH also contributed to an educational trifold pamphlet entitled "Silica... It's Not Just Dust: What rock drillers can do to protect their lungs from Silica Dust." This pamphlet won the U.S. Public Health Service Engineering Literary Award on June 9, 1998 and had very wide distribution that assisted the education of drillers to the hazards of respirable silica dust and silicosis.

Assessment of Hazardous Waste Abatement Workers' Workload

Project Period:
1994 - 1997

Researcher Name:
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NIOSH

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Key Partner(s):
n/a

Co-Investigator(s):
Jean-Louis Belard, MD
U.S. Army, Ft. Dietrick, MD

Abstract:
Hazardous waste abatement workers often perform their tasks in hot environments while wearing completely encapsulating chemical protective clothing and full respiratory protection. They are at increased risk of heat stress. This study evaluated the amount of energy expended during six simulated waste abatement tasks in hot, warm, and neutral environments. The results indicated that physiological responses to wearing prescribed totally encapsulating gear while working in hot, warm, and neutral environments vary greatly among participants. Such variability hinders the design of universal work-rest recommendations. Micro-cooling systems are a potential solution to heat stress for workers who use totally encapsulating suits for their jobs.

Impact:
This study provided basic data for the safety research community in determining research direction to reduce heat-stress potentials among hazardous waste abatement workers.

Anthropometry of Agriculture Populations

Project Period:
1996 - 2003

Researcher Name:
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NIOSH

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Key Partner(s):
Tim Fisher
American Society of Safety Engineers

Garry Pollack
Society of Automotive Engineers
Bruce Bradtmiller
Anthrotech
Jennifer Whitestone
Total Contact Inc.

Co-Investigator(s):
Richard Whisler
NIOSH
Tsui-Ying Kau
NIOSH
Joyce Zwiener
NIOSH
Jinhua Guan, Ph.D
NIOSH

Abstract:
This project studied the three-dimensional human form of agriculture workers for evaluating the interaction of workers with farming tractors. The major efforts completed were the development of human models for quantifying 3-D human shapes and sizing information for machine and personal protective equipment design applications, and the formulation of anthropometric criteria for the design of farming tractors and rollover protective structures (ROPS) to increase the safety of farming tractor operation.

Impact:
This study provided the first available detailed 3-D and traditional anthropometric information about agriculture workers, which is valuable for the design of farm machines and agriculture-related personal protective equipment. The identified 15 body models can serve as useful design targets to test current tractor design until a larger survey of the nation's agriculture workers can be done.

Preventing Injuries from Falling Rock in Underground Coal Mines

Project Period:
2000 - 2005

Researcher Name:
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Key Partner(s):
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Geologist Anker Energy
John Rusnak
Peabody Coal Co.
Donnie Pauley
Peabody Coal Co.

Co-Investigator(s):
Dennis Dolinar
NIOSH
Susan Robertson
NIOSH
Dave Oyler
NIOSH

Abstract:
Roof falls result in more than 500 injuries a year. The objective of this project is to reduce the risk of injury from rock falls in underground coal mines by removing the barriers that limit the use of surface control technology. Barriers include cost, difficulties in installation, time constraints, and perceived safety problems.

Impact:
The greatest impact of the project will be to convince mine operators that rock fall injuries are entirely preventable. This has been done by making it clear that small rocks are defeating conventional roof support. NIOSH data has demonstrated to mine operators that screening roof with welded wire screen will reduce injuries. NIOSH field demonstrations have also shown that wire screen installation can be accomplished with minimal time costs. NIOSH training materials have been embraced by the industry and MSHA and will help speed the acceptance of screen for reducing rock fall injuries. NIOSH has developed and is promoting in the field the personal bolting screen (PBS) as an ergonomically-safe small screen for use in low seams.

Assessment of Asphalt Fume Exposure from Roofing Kettles

Project Period:
1997 - 2004

Researcher Name:
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NIOSH

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Key Partner(s):
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Owen Corning
Amy Reeves
Reeves Roofing Equipment
John Cleasby
Cleasby Manufacturing
Don DuBue
National Tool and Equipment

Co-Investigator(s):
n/a

Abstract:
This project was a study to evaluate existing engineering controls in reducing worker exposures to asphalt fumes during roofing installation operations. Control systems evaluated included low fuming asphalt, afterburner/safety loading door systems, and an air filtration system.

Impact:
This project provided evidence that control technology exists that can effectively reduce worker exposure to asphalt fume during the roofing process. When low fuming asphalt was used, large, statistically significant reductions were measured for the kettle operator as compared to using conventional asphalt. The results from surveys that studied afterburner systems or air filtration systems were inconclusive. Low fuming asphalt is currently being used by some contractors. The results from this project give further evidence that exposure reductions are achieved when low fuming asphalt is used.

Industrial Ventilation Systems Research

Project Period:
2002 - 2010

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Abstract:
Laboratory research will be conducted to determine the efficacy of industrial ventilation filters and sorbent materials against various aerosol and/or vapor exposure scenarios. This research will assess the overall performance and efficacy of these environmental ventilation systems against particulates and organic vapors, as well as look at aerosol/vapor interactions that could affect overall ventilation system performance. Field evaluations will be conducted to study the efficacy of entire ventilation systems over time, focusing on the use, care and maintenance of the system, the sorbent and filter replacement schedules, and the performance of the old system filters and sorbent beds. Models of the performance of industrial ventilation filters and sorbent materials, and models for predicting filter/sorbent breakthrough and setting more reliable replacement schedules will be developed.

Impact:
This research project will assess the overall performance and efficacy of these environmental ventilation systems to remove particulates and organic vapors, as well as look at aerosol/vapor interactions that could affect overall ventilation system performance. The impact of this project will be better protection for workers and surrounding communities by improving ventilation systems and developing protective sorbent/filter change-out schedules.

Respirator Filter Degradation/Organic Vapors and Workplace Aerosols

Project Period:
2001 - 2002

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Abstract:
This project is the continuation of a project that began in 1999 and was transferred to the National Personal Protective Technology Laboratory (NPPTL). Filters were exposed to different organic vapor concentrations in the laboratory and to aerosols in selected workplaces for varying amounts of time. The filters were tested using the standard NIOSH testing methodology for evaluating particulate respirator filter efficiency to determine if filter degradation is occurring. Filter efficiency testing was conducted using a solid sodium chloride aerosol and/or a liquid dioctyl phthalate (DOP) aerosol. Efforts

were made to describe the chemical/physical mechanism(s) responsible for this phenomenon (possibly including electron microscopy). The data was disseminated to particulate filter respirator users and recommendations were provided to NPPTL for revisions to NIOSH policies and Federal regulations, as appropriate.

Impact:
The problem of electrostatic filter degradation could pose a significant threat to all users of these filters under certain exposure and use patterns. Industrial hygienists, safety professionals, and respirator users were informed of potential filter efficiency degradation issues with newer electrostatic filter media under certain aerosol and vapor exposures and respirator use patterns. Respirator manufacturers have been forced to acknowledge this potential degradation problem and are addressing the issue with increased industry research. Based on the results of this project and a previous PAPR project, recommendations for new, more stringent PAPR filter and PAPR unit integrity certification test criteria were submitted to the NIOSH Respirator Branch for promulgation in an updated 42 CFR 84 standard module. These new criteria will provide a significantly enhanced level of protection for the estimated 500,000 PAPR users in the American workforce.

Lockout/Tagout, Jammed and Moving Machinery Controls

Project Period:
2001 - 2005

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Richard C. Wang
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Abstract:
The purpose of this research is to develop practical monitoring, warning, and interlock devices that industry can license and further develop into commercially available safety products for conveyors and underground mining machinery. These devices will be designed to warn employees of their proximity to a potentially hazardous work area, and, if necessary, shut down the equipment. The research team will ensure that any interested stakeholders become aware of the capability of this new technology through an Open Industry Briefing in August 2005 and publications in peer-reviewed journals. Licensing agreements and cooperating product development efforts are being vigorously pursued with appropriate vendors. Both fatalities and injuries due to workers becoming caught in moving conveyors and mining machinery are expected to significantly decline in industries where this type of technology is successfully implemented.

Impact:
NIOSH impact on traumatic worker injuries and fatalities is anticipated to be minimal for the next several years until these systems have been made into commercially available products and are then incorporated or retrofitted into conveyors and mining machines. Information dissemination of this new technology is being accomplished via presentations at conferences and articles in journal publications. An Open Industry Briefing titled "Proximity Warning Systems for Underground and Surface Mining" will be held at PRL in August 2005 in which sensor manufacturers and mining companies will be invited to participate. After the HASARD technology becomes commercially available and adapted by industry, other related spin-offs of this type of machine safety technology as applied to mining, manufacturing, construction, and agriculture are expected to be developed.

Environmental Tractor Cab System Integrity

Project Period:
2001 - 2005

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Abstract:
This project provided a critical link in the process of determining the cause(s) of hazardous exposure within enclosed environmental tractor cabs used in agriculture, construction, and mining. The testing methodology that is used to evaluate particulate filter efficiency and aerosol particle counter to identify leak sites and evaluate total cab integrity was used. Equipment manufacturers, custom pesticide applicators, and NIOSH researchers collaborated to incorporate the measurement of aerosol penetration into environmental enclosures. All phases from manufacturing and design through audits to routine maintenance applicability were evaluated, and appropriate aerosol test methodology was incorporated to provide for a total/cab performance program. NIOSH has developed a rapid 15-minute test that can be performed on every cab during both production and maintenance phases.

Impact:
NIOSH has been collaborating with a number of partners to improve methods for testing and evaluating environmental agricultural tractor cabs. The collaboration with Nelson Manufacturing has resulted in the manufacturer incorporating numerous NIOSH suggestions for improvement into the design and testing of their manufactured cabs. These enhancements include: (1) cabs that are now fitted to each specific tractor permanently at the manufacturing facility to eliminate potential leak sites due to improper fit or due to use and (2) the addition of a controlled leak site allowing the recirculation of previously filtered air to further reduce the contaminant levels. The same manufacturer has instituted a NIOSH-developed stationary test employing optical particle counters into a program at their facility to check new cabs for system integrity prior to their release. The ASAE-PM 03/16 committee has revised the ASAE-S525 standard to remove all statements saying that enclosed tractor cabs can be used in lieu of respirators.

Enhanced Spray Dust Capture to Suppress Silica Dust

Project Period:
1999 - 2004

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Co-Investigator(s):
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Abstract:
The goal of this research was to develop enhanced spray dust capture principles for improving water droplet collection efficiency of respirable silica dust. This project measured spray droplet characteristics of various spray nozzle types; studied geometric spray nozzle layout enhancements for improving water droplet to air induction performance; and measured airborne dust capture or removal rates of these particular geometric spray nozzle layouts. Test results determined that there are trade offs between air inducement and dust capture efficiency. These findings were used to develop a water-powered scrubber that will be tested for dust control improvements in several mining applications.

Impact:
This research provided the fundamental knowledge for a newly funded project proposal to reduce both coal and/or silica exposure of mine workers by improving airborne dust capture efficiency of mining machine spray systems. In the new project, dust reduction improvements will be addressed through novel application of lower pressure water powered in-line series scrubbers and more effective utilization of water droplet size and velocity properties of various spray nozzle designs. Applied dust control research of spray and scrubber principles will be studied in PRL's mine test gallery with field demonstration at a limited number of mining operations. Applied demonstrations of more effective spray and scrubber system principles will provide the various mining commodity operations with an evolving design methodology for advancing water dust control applications. Project success will provide the dust control application tools necessary to achieve a healthier environment for mine workers.

Development of Automatic ROPS Overturn Sensor

Project Period:
1994 - 1999

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n/a

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Art Hudson
NIOSH

Abstract:
This project, in conjunction with the project Development of an Automatically-Deployed ROPS, developed a prototype automatically-extending roll bar for agricultural tractors. The need for such a device was warranted as tractor overturn fatalities were, and still are, the leading cause of agricultural machinery- related fatalities. This structure will normally be stored out of the way, but will extend to its full dimensions to protect the operator in the event of an overturn. This project developed the sensor, which will identify an impending overturn and extend the roll bar. The sensor development was dependent on an algorithm that reliably predicts overturns without an undue number of false alarms. The sensor was evaluated through laboratory and field testing. Field testing was performed with an instrumented, unmanned tractor, and included the testing sequence prescribed in SAE Standard J2194.

Impact:
In July of 2000, the results from this project, along with the project Development of an Automatically-Deployed ROPS, were presented at the 93rd annual international meeting of the American Society of Agricultural Engineers. The results were also presented in October of 2000 at the National Occupational Injury Research Symposium. The team also published the results in two journals (listed below). The main impact of this work was proof a sensor could be developed that could reliably predict the unsafe operating condition of a tractor and deploy a compressed ROPS in a timely fashion to prevent the tractor from completely rolling over. This work, in conjunction with the work on "Development of Automatic ROPS" also satisfied the requirements of the SAE J2194 standard. Finally, this work directly contributed to the development of a new NORA project concept,"New Technology to Increase ROPS Use on Tractors," that successfully competed and was awarded funding in 2000.

Respirator Approval: Policy and Standards Development

Project Period:
1988 - 2011

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Bituminous Coal Operators Association (BCOA)

Mine Safety and Health Administration (MSHA)

National Mining Association (NMA)

United Steel Workers of America (USWA)

Co-Investigator(s):
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Robert Stein
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Abstract:
The purpose of this project is to develop and promulgate improvements to respirator certification policies and regulations to allow respirator end users to take advantage of new and emerging technologies in the area of respiratory protection. The upgrades will encompass the performance parameters for the various respirator types, quality assurance provisions, and modernizing the certification process. The impact will be that workers receive improved respiratory protection through the use of state-of-the-art respirators and are able to protect against new and emerging respiratory hazards. Program improvements will come about through the use of third-party testing labs, third-party auditors, and stakeholder participation.

Impact:
Respirator certification standards need to be consistent with contemporary technology. Technology and newly emerging hazards have out-paced the existing requirements that were first promulgated in 1972. The goal will be to revise the standards to contemporary levels incorporating state-of-the-art test methods and improved quality assurance requirements in incremental rulemaking steps and policy development. This

project represents a continuous improvement strategy for the respirator certification program.

Dust Control for Longwall Mining

Project Period:
1997 - 2007

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Mine Safety and Health Administration (MSHA)
National Mining Association (NMA)
Foldel Creek Mine – Twentymile Coal Company
Emerald Mine – RAG Emerald Resources Corporation

Co-Investigator(s):
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NIOSH
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NIOSH
Greg Chekan
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Abstract:
The objective of this multi-tasked research program is to reduce the respirable dust exposure of mine workers at longwall mining operations. Laboratory testing will be conducted to evaluate: optimum operating levels for water and air application for multiple operating conditions, respirable dust entrainment in high velocity airstreams and the feasibility of implementing advanced control techniques on longwalls. Mine site evaluations to benchmark available control technologies will be conducted, as well as, evaluations of new controls as they are developed. Research results will allow longwall operators to select dust control technologies that are most appropriate for their specific operating conditions and offer alternatives to traditional control techniques.

Impact:
Successful completion of this research project will result in the development of improved dust control technologies/practices that can be adopted by longwall operators throughout the United States. Specific tasks should: (1) develop a "Best Practices" handbook to guide longwall operators in the application of dust control technology, (2) advance the knowledge of dust entrainment in high velocity airstreams leading to improved dust control during shield advance, and (3) develop and demonstrate the potential of advanced control technologies, such as the water-powered scrubber. Data obtained from this research should assist mine operators in reducing overall dust levels along the longwall face by selecting appropriate dust control parameters for their unique operating conditions.

Footwear for improved balance control in construction work

Project Period:
2001 - 2004

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Co-Investigator(s):
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Abstract:
This laboratory study used virtual reality technology to evaluate footwear style effects on workers' instability at elevation. Construction workers performed standing and walking tasks with three athletic and three work shoe styles on 10" and 6" wide planks on a virtual roof. Trunk and foot kinematics and workers' perceptions were collected using a balanced experimental design. Dependent variables included angular velocity of the trunk and the rear foot, and perceived instability and comfort. The study demonstrated that workers' balance on elevated and narrow surfaces was significantly improved with footwear styles which provide good motion control, and shoes with high upper, i.e., boot style. Overall, the study indicated proper shoe selection and improvements in the design of specialized work footwear would enhance workers' stability at height, and can be an effective intervention strategy to reduce the risk of falling.

Impact:
The study contributions will be to the advancement of knowledge in the area of balance control, and the role of sensory interfaces, i.e., footwear – an area in which active research is ongoing. Specifically, the study results indicate a good potential for developing practice-centered interventions. One measurable impact of the study is that it triggered a new NORA-related research project, entitled "Sensory-enhanced balance control at elevated workplaces." The new project will explore the potential effectiveness of an emerging technology

"randomly-vibrating shoe inserts," which is expected to improve workers' balance when working at heights.

Dust Suppression Methods in Abrasive Blasting

Project Period:
1997 - 2000

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Abstract:
Abrasive blasting with sand can generate high concentrations of respirable quartz dust and cause silicosis and death in overexposed workers. NIOSH data that were collected in a laboratory study for a different purpose were analyzed for possible relationships between sand characteristics and the amount of respirable dust that was produced. The data analysis suggests that sands with smaller initial particle sizes create substantially lower levels of respirable quartz dust and that a commercial dust suppressant additive can reduce exposures even more, all without reducing productivity. Substituting a less toxic material for sand in abrasive blasting should be the first control considered in any operation. However, these results suggest that additional research would be worthwhile to test the hypothesis that if sand is used, respirable quartz airborne concentrations might be reduced by selecting abrasive sands with smaller initial particle sizes and adding a commercial dust suppressant.

Impact:
Substituting a less toxic material for sand in abrasive blasting should be the first control considered in any operation. However, if sand is to be used, analysis of these data suggests that additional research would be worthwhile to prove or disprove the hypothesis that respirable quartz airborne concentrations might be reduced without sacrificing blasting performance by selecting abrasive sands with small initial particle sizes and adding a commercial dust suppressant.

Improved Equipment Design Through Applied Anthropometry

Project Period:
2001 - 2005

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Key Partner(s):
National Fire Protection Association
Consensus Standard Organization

American National Standards Institute
Consensus Standard Organization

Society for Automotive Engineering
Consensus Standard Organization

FEMCOROPS Manufacturer

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Richard Whisler
NIOSH

Abstract:
This project utilizes unique human-sizing techniques for methods development to improve fit assessments and the design of personal protective equipment (PPE) and work environments for reducing the occurrence of traumatic injuries in the workplace. In particular, methods for assessing fit for designing better fitting protective gloves will be developed and techniques to evaluate eye coverage provided by safety eyewear will be suggested. The third portion of this project will examine the protective volume required around an operator in the event of tractor rollover. This will help rollover protective structures (ROPS) designers determine the size and stiffness required in these structures. NIOSH researchers will work with trade groups and standards organizations to ensure that the results of this research are widely disseminated.

Impact:
At the completion of research activities and subsequent dissemination of findings and written recommendations to U.S. consensus standard setting groups, the expected impact from the three project sub-components includes the development of science-based datasets to justify: (1) recommendations to revise the existing NFPA glove sizing certification specifications, (2) a standard methodology for calculating a coverage coefficient for ANSI Z87 eyewear safety products, and (3) recommendations to revise SAE consensus standards for

off-road vehicle safety that include performance criteria for the clearance zone volume and safer seat design criteria to reduce the severity of roll-over impact on the human operator.

Coal Mine Face Methane Control and Monitoring

Project Period:
1999 - 2007

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MSHA

Co-Investigator(s):
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Abstract:
The potential for methane frictional ignitions exists in most coal mines. Research conducted in the Pittsburgh Research Laboratory's ventilation test gallery has led to improved techniques for reducing methane levels underground and monitoring methane concentrations near the mining face. However, the complexity of airflow patterns at the face makes it difficult to predict when and where methane concentrations might exceed the lower explosive limit. While it is impossible to model and study each gallery condition that affects changes in face methane levels, for a specific test sequence the ranges of operating conditions for a single mining cut sequence can be evaluated. Simple mathematical models, based on experimental results, estimate effects not directly observed. Results have shown that variables, such as air quantity and entry width, can affect airflow patterns and methane concentrations near the face. Present research is more accurately defining the relationship of face air velocities and methane levels.

Impact:
NIOSH conducted laboratory tests to evaluate procedures for improving estimates of face methane concentrations. Based on the results, the Mine Safety and Health Administration (MSHA) has already issued a variance that allows a mine to modify its face methane sampling procedures. MSHA has also modified their methane sampling requirements during roof bolting, again based upon the results of NIOSH ventilation gallery studies. Many room-and-pillar mining sections use water sprays and a machine-mounted air scrubber to improve airflow to the face and reduce methane levels. The guidelines for using these water sprays and scrubbers are largely based on results obtained in the ventilation gallery. NIOSH has provided face study data to the University of Kentucky's Mining Engineering Department. This information has been used to examine computational fluid dynamics as a technique for evaluating underground coal mine face ventilation systems. Results were compared and validated for some of the flow conditions.

Ventilation of Large Opening Mines

Project Period:
1999 - 2004

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Co-Investigator(s):
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NIOSH

Abstract:
The objective of this work was to enhance the understanding of air movement within large underground mines, i.e. those entries having entry heights greater than 10-ft high and a cross-sectional area of at least 200-ft2. Many U.S. metal/nonmetal mines, such as salt and limestone, often have openings greater than 1,000-ft2. It is almost impossible to maintain adequate air movement in large entries. These openings rapidly deplete the momentum of air entering a mine, causing air movement to slow within a short distance. Because of low air velocities, the large entries and their associated face areas are prone to air stagnation and recirculation. In some cases, air can actually be moving in opposite directions at different elevations within the same entry. This multi-year effort attempted to develop a technology ensuring the accuracy of low velocity instruments. The resulting device was used to examine the likelihood that low air velocities could be accurately examined.

Impact:
There are presently no devices available within the United States that are capable of ensuring the accuracy of anemometers at air velocities below 30 ft/min. The objective of this program was to provide new and improved knowledge relative to the ability to replicate specific LAVA air velocity evaluations at velocities less than 20 ft/min. Ultimately, the measure of this research will be industry acceptance of this device as an instrument that is capable of calibrating air measuring instruments at reduced air velocities. Due to funding restrictions, research efforts of this program have been stopped.

Development of an Air-Purifying Respirator CO2 Test Using the Automated Breathing and Metabolic Simulator (ABMS)

Project Period:
2000 - 2002

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NIOSH
Industrial Safety Equipment Association (ISEA)
Respirator trade group
National Fire Protection Association (NFPA)
Firefighters group

Co-Investigator(s):
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NIOSH
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Abstract:
The project related to the NORA initiative on control technology and personal protective equipment. It has been estimated that several million workers are required to wear respirators. Elevated inhaled carbon dioxide concentration is an inherent aspect of respirator wear. The physiological effects of breathing 3 - 4% inhaled CO2 are hyperventilation and headache. No NIOSH certification test existed to measure average inhaled CO2 concentrations for any class of air-purifying respirators at the time of this project's completion. The major goal of this study was to develop an Automated Breathing and Metabolic Simulator (ABMS) -based test for measuring average inhaled CO2 concentrations for all classes of air-purifying respirators. Objectives were to design ABMS test protocols which could form the basis for NIOSH CO2 certification tests for air-purifying respirators and to test representative air-purifying respirators to characterize their performance in terms of inhaled CO2 concentrations.

Impact:
In mid-2003, using the test protocols developed for the ABMS under this project, preliminary data were collected at the National Personal Protective Technology Laboratory, NIOSH, indicating elevated levels of inhaled carbon dioxide in three recently marketed escape respirators. These escape respirators had been purchased in large numbers by the Pentagon, Congress, and the Manhattan Transit Authority for their workers after the September 11 terrorist attacks but were not NIOSH-approved. As a result of NPPTL testing, concerns about the safety of these escape respirators were significant enough that in August 2003, OSHA published a Safety and Health Information Bulletin (SHIB) titled "Chemical, Biological, Radiological, and Nuclear (CBRN) Escape Respirators." This study also prompted the proposal by NIOSH of several new CO2 tests for air-purifying respirator certification and the initiation of a NIOSH standards development program that will result in new certification test criteria for CBRN escape respirators.

Development of Computer-Aided Face-Fit Evaluation Methods

Project Period:
2001 - 2005

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Co-Investigator(s):
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Abstract:
Existing data on the head and face of U.S. workers is woefully inadequate and out of date. Current respirator fit test panels are based on 1960s' military data. Worker demographics have changed in the past 30 years. The goal of this project is to develop computer-aided, face-fit evaluation methods. Specific aims are: (1) to establish fit test panels representing today's workforce to be incorporated into the NIOSH respirator certification and international standards; (2) to investigate the correlation between 3-D parameters and face fit; and (3) to develop computer-aided, face-fit evaluation methods that can be used to screen out respirators with characteristics that fit poorly, and design well-fitting respirators.

Impact:
The impact of the outputs can not only be seen immediately, but also have a long-term significance to the industry. The results have been incorporated into the NIOSH Standard for CBRN escape respirators. The new respirator fit test panel will be incorporated into the NIOSH total inward leakage certification standard currently under development. Respirator manufacturers will use this data to improve the face seal characteristics of their products. All of these will improve the

health and safety of the nation's workers. ISO TC94 SC 15 WG1 PG5 is also waiting for the results of this project to be incorporated into the ISO standards.

Performance Tests for High APF Respirators

Project Period:
2001 - 2005

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Co-Investigator(s):
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NIOSH

Abstract:
The goals of this project are to strengthen the scientific basis on which NIOSH policies and recommendations for respiratory protection depend, and to develop a validated, complete respirator performance test for high APF respirators to be incorporated into the NIOSH certification program. The specific aims of this project are: (1) to compare fit factors from six quantitative fit test methods to Freon exposure dose; (2) to validate performance tests as a condition of certification; and (3) to provide technical assistance in the development of the NIOSH total inward leakage test program.

Impact:
This project showed the relevance of fit testing as part of a respiratory protection program. Quantitative fit factors showed meaningful respirator performance indicators in an actual workplace environment. As such, this study identifies characteristics of fit factor tests which may lead to developing a fit factor test that more accurately predicts workplace performance factors. The findings from the analyses of ambient aerosol concentration and fit factor are being incorporated into the total inward leakage test protocol. The expected outcome will also include validation of performance tests for high APF respirators to be incorporated into the NIOSH certification program. Research results will be used to justify the appropriateness of performance tests as a condition of certification. Results of this project could also be used by OSHA and MSHA to set APFs.

• Emerging Technologies •

Statistical Methods Development and Application

Project Period:
1999 - 2010

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Co-Investigator(s):
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Shengqiao Li, MS.
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Abstract:
This project provides the resources for independent research on statistical methods, using the latest technology. New statistical methodologies will be developed, new applications will be explored, and the project will provide support for initial studies that are deemed significant to future research. Current activities supported by this project are exploration of appropriate statistical analysis methods for analysis of proteomics research, modeling of brachial reactivity curves, and analysis of heart rate variability data. While in the past there has been some focus on developing theoretical results, at this time there is more focus on development and application of new statistical methods for application to problems in occupational health. The creation and implementation of appropriate statistical methods and study designs will allow researchers to better interpret data and, therefore, allow information and knowledge gained through research to be more effective in preventing death and injury among the US workforce.

Impact:
Impacts on worker health through publication of results in the statistical methods literature are indirect. This research also has a direct impact on the quality of research efforts at Health Effetcts Laboratory Division (HELD), NIOSH. By providing improved statistical methods for design and analysis of data from various projects in this division, this project directly improves the quality of publications and recommendations produced by HELD investigators with whom BEB collaborates.

Smart Fire Sensors

Project Period:
1998 - 2003

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Key Partner(s):
Foundation Coal Company

Co-Investigator(s):
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Abstract:
To protect miners in the workplace from hazardous smoke and combustion gases associated with mine fires, improved mine fire detection technologies were investigated that resulted in the development of smart mine fire sensors capable of providing early mine fire detection, discriminating a mine fire from diesel emissions, determining the stage of fire growth, and determining the fire combustion source. There is an increased need for early and discriminating mine fire detection as advanced mining technology rapidly increases the underground mine region occupied by miners to be monitored. This project used the unique research expertise and Safety Research Coal Mine (SRCM) at the Pittsburgh Research Laboratory.

Impact:
The impact of this research has been an increased awareness in the mining community of the advantage of multiple-type mine fire sensors for early and reliable mine fire detection. A workshop was conducted in 2004 bringing together sensor and mine monitoring system manufactures, mine operators, and government and labor officials. As a result of the workshop, a partnership was formed with Foundation Coal Company and Conspec, a company that manufactures mine monitoring systems that resulted in an in-mine evaluation of the sensors and neural network at a mine in Pennsylvania.

Integrated, Intelligent Ensembles Project for Firefighters (formerly the Homeland Emergency Response Operations and Equipment Systems - HEROES)

Project Period:
2003 - 2013

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Abstract:
The Integrated, Intelligent Ensemble Project (formerly HEROES) is a long-term R/D effort to develop an advanced firefighter ensemble with enhanced protection against chemical/biological hazards, structural fires, integrated electronics that include monitoring location, monitoring physiological parameters, and advanced communications. We have received a final report from Dr. Roger Barker (NCSU) detailing the gaps in test methodologies for the appropriate testing of a prototype ensemble. We have an Interagency Agreement with the National Protection Center/Natick Soldier Center to provide a detailed report on a future hazards analysis and the gaps in current firefighter ensemble technologies that need to be filled to address those threats (report pending March 2005). We have been engaged by the Technical Support Working Group (TSWG) to perform a laboratory assessment of the physiological "burden" imposed by wearing a new prototype ensemble with enhanced chemical/biological hazards protection. Physiological testing of the ensemble is anticipated to begin mid-summer 2005.

Impact:
The fully integrated, intelligent ensemble program has not yet impacted the work force because it is still in the early stages of development and implementation.

• Exposure Assessment Methods •

Pesticides by GC-AED

Project Period:
2001 - 2005

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Abstract:
Pesticide use is widespread, and there are hundreds in use (some illegally). Our laboratory is investigating gas chromatography with atomic emission detection (GC/AED) as a screening method for a broad spectrum of pesticides. The AED detects any element in GC-amenable compounds at picogram (10-12 g) levels. This specialized instrument is not routinely available. Unlike most detectors, the AED should allow a compound independent calibration (CIC) for many compounds. CIC simplifies instrument calibration because the calibration solution must only contain the element of interest, not the analyte itself. The AED also permits calculation of elemental ratios. When combined with results for GC/mass spectrometry (GC/MS), elemental ratios simplify the identification of pesticides and any non-target compounds that may be present. Prior to analysis, a field sample (e.g., house dust) must be extracted to remove the pesticide contaminants. A relatively new extraction technique is being evaluated.

Impact:
Powerful, new analytical capability has been established in our laboratory. The overall impact of the project cannot be assessed now because this capability has not yet been applied to field studies. Possible pesticide-related applications include: epidemiological studies, surveillance activities, evaluation of mitigation measures, and metabolite analyses. Beyond pesticides, example applications include sulfur compounds in diesel fuels/emissions and chemical warfare agents. Collaborations on future projects are being explored

Longitudinal Surveillance/Beryllium Disease Prevention

Project Period:
1997 - 2010

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Abstract:
Chronic beryllium disease is an incurable lung disease that develops in individuals who become sensitized to the metal beryllium. Occupational exposure may occur in metal fabrication, the nuclear industry, dental laboratory work, and electronics applications, among others. This research is focused on understanding the key risk factors predicting beryllium-related health outcomes, and evaluating preventive strategies that are implemented. The specific aims include (1) evaluating the best metric for assessing exposure to airborne beryllium in relation to risk of sensitization and chronic beryllium disease; (2) understanding the possible role of dermal exposure in development of sensitization to beryllium; (3) understanding the interaction of genetic factors in exposure-response relations; (4) evaluating the effect of exposure cessation on risk of sensitization and/or progression to chronic

beryllium disease; and (5) using longitudinal surveillance to gain a better understanding of the true burden of disease in exposed workers.

Impact:
The failure to prevent beryllium sensitization through engineered reductions in airborne exposure levels motivated the company and NIOSH to consider the potential importance of dermal exposures, and skin protection was implemented. This was part of a larger program that included improved housekeeping procedures and increased respiratory protection. Because the success of interventions could best be evaluated by testing new workers, the company started screening at hire and at 3, 6, 12, and 24 months. Medical surveillance of new hires showed that sensitization within the first two years of employment fell to 1.1%, in comparison to 11.9% in 1998. The success of this comprehensive protection program has been replicated at the company's other facilities and information is now being disseminated to the company's customers. Results of our research are being circulated to OSHA, the Department of Energy, and to the industry in general through a NIOSH Alert, now in review.

Technical Support for NMAM 5040

Project Period:
2001 - 2003

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Abstract:
Workers exposed to diesel exhaust show an elevated risk for lung cancer. Noncancer health effects also are associated with diesel exhaust, including immunologic, respiratory, and cardiovascular effects. Over one million U.S. workers are exposed. Concentrations are especially high in mines—sometimes as much as 1000 times higher than environmental levels. In 1996, NIOSH published Method 5040, which measures the organic and elemental carbon (OC and EC) content of diesel particulate matter. Interest in 5040 became widespread. Also, the Mine Safety and Health Administration (MSHA) recommended it for compliance determinations in metal/nonmetal mines. Technical support was needed by MSHA and many others (EPA, industry, industrial hygienists, university researchers) that were applying the new method to both occupational and environmental monitoring. This project provided that support and also addressed methods standardization.

Impact:
Monitoring exposures to diesel particulate matter (DPM) and other types of fine particle pollution are important because studies show a positive association between airborne levels and respiratory illness and mortality. In 1996, NIOSH published a new monitoring method (5040) for DPM, which has been recognized internationally. NIOSH 5040 was recommended by MSHA for compliance determinations in metal and nonmetal mines. Other applications include industrial hygiene surveys, epidemiological studies, emission testing, and air pollution monitoring/research. Recently, 5040 was even applied to measurements on ice cores from Mt. Everest and the Tibetan Plateau. This project provided direct support to many individuals engaged in these activities. It also addressed standardization. Standardized methods are needed to quantify the potential health effects of DPM and make comparative analyses of different studies possible. Quantitative data are lacking and central to the establishment of sound regulatory standards.

Computational Fluid Dynamics Simulations

Project Period:
2000 - 2003

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Abstract:
Accurate performance of aerosol samplers is critical for industrial hygienists' successful efforts to protect workers. Performance assessments of personal samplers are conducted in controlled environments so unknown sources of variability will not influence the results. These performance evaluations are usually conducted in wind tunnels. However, recent advances in high-performance computing and flow modeling software have made it possible to evaluate sampler performance with simulations. In this work, simulations were conducted for air and particle behavior near the inlet of the GSP and IOM Inhalable aerosol samplers. Steady-state, 3-D simulations were conducted using the FLUENT CFD solver. Particle trajectories were calculated in a Lagrangian reference frame on the velocity fields. Sampling efficiencies were calculated and compared to those reported in the literature. They

were found to have similar trends for particle sizes up to 40 micrometers. It was concluded that CFD can be used to evaluate the performance of personal samplers.

Impact:
This project allowed detailed investigations of sampler designs and the performances of real aerosol samplers were studied. A key area of focus for this work has been in the analysis of data obtained from CFD simulations so that appropriate conclusions can be made about the health and safety of workplace environments. Two important methods used in CFD analysis have been given attention so they are on the forefront of future CFD work in this field. Specifically they are grid-convergence and parameter-space analysis. Use of these methods allows the results of CFD to be legitimately used for making sound conclusions about the particular scenario for which a simulation is made.

Exposure Assessment Methods for Evaluating Electric and Magnetic Field (EMF) Health Effects

Project Period:
1997 - 2004

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Abstract:
This project developed new instruments and methods for assessing exposures to electric and magnetic fields (EMF) in order to better evaluate whether occupational EMF is a risk factor for cancer and neurodegenerative diseases. First, a new magnetic field monitor, the Multiwave III, and associated software were developed in order to measure workers' personal exposures to magnetic field characteristics that may have biological effects. This instrument is now being used to measure exposures in electric utilities where epidemiologic data on cancer already exists. Second, existing magnetic field measurements have been assembled into a job-exposure matrix (JEM), which has been used in several epidemiologic studies. A NIOSH study with this JEM found that workplace magnetic fields are associated with elevated risks of Alzheimer's disease, Parkinson's disease, and amyotrophic lateral sclerosis (ALS). Lastly, NIOSH is assisting with the assessment of occupational radio-frequency EMF in an international study of brain cancers.

Impact:
Because EMF from AC electricity was declared a Possible Carcinogen by NIEHS and IARC, the government is often asked for advice on dealing with this uncertain health risk. To help address this problem, NIOSH maintained a small research program on EMF exposure assessment, and developed partnerships with EPRI, IARC, and NCI to use these new methods in epidemiologic studies. These studies evolved slowly, but were designed to eventually provide important new evidence on whether EMF is really a health risk. A more immediate impact is the higher level of expertise NIOSH has in assessing and managing EMF's possible health risks. This project provided additional information for workers and managers to guide them through the uncertainties about health effects of EMF, through documents, web information, and direct responses to inquiries. NIOSH has recently assisted NASA, the Minnesota Department of Health, and the State Department with managing EMF exposures.

Perchloroethylene: Biomarkers for Human Exposure

Project Period:
1997 - 2000

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Abstract:
Epidemiologic studies consistently show increased risk for cervical and other cancers in women drycleaners. Perchloroethylene (PCE) is classified as a probable human carcinogen, and is the solvent of choice in U.S. dry cleaning shops. Our objectives were to develop methods for biomarkers of exposure, effect of exposure, and susceptibility to use to measure internal dose and to evaluate risks of exposure to PCE. The project included 18 female drycleaners and 20 unexposed female laundry workers. Distribution of a polymorphism in one gene important in PCE metabolism was significantly different between the drycleaners and the laundry workers. A method developed to measure potentially genotoxic urinary metabolites of PCE showed trace levels of these metabolites in several of the drycleaners; only a few had levels above the limit of quantitation. Women drycleaners had lower levels of oxidative DNA damage than laundry workers. PCE exposures were well below recommended exposure limits in all facilities.

Impact:
The methods developed to extract and quantitate perchloroethylene (PCE) metabolites offer significant advantages over typical extraction and derivatization procedures for GS-MS analysis of the same compounds. PCE internal exposure levels for various exposure situations can be rapidly quantified by analysis of these metabolites: over 50 urinary specimens can be analyzed in an automated system in 24 hours. The time-weighted PCE concentration for 17 of the 18 drycleaners in this study was below 5 ppm, but potentially higher levels of exposure to PCE are found in other industries where PCE is used as a degreaser. Contrary to the original hypothesis, an inverse association was evident between blood PCE levels and oxidative DNA damage. Another factor(s) not assessed in the present study may be responsible for the difference in oxidative DNA damage between drycleaners and laundry workers. Results from this study advanced the body of knowledge regarding workplace exposure to PCE.

Diesel Engine Emissions Measurement and Analysis

Project Period:
1996 - 2003

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Abstract:
Over 30,000 underground mine workers are exposed to excessively high levels of diesel exhaust particulate matter (DPM), declared to be a possible carcinogen by NIOSH and others. Upon closure of the Bureau of Mines research in Minneapolis, their project, which focused on developing methods to measure worker exposure to DPM at levels that were protective, was moved to Pittsburgh to form the foundation of diesel exhaust monitoring and control research in NIOSH. This project focused on setting up an experimental diesel exhaust exposure chamber, advancing and verifying the NIOSH Analytical Method 5040 for carbon and developing an effort to commercialize and verify performance of the size selective sampler to enable DPM sampling in the presence of coal and metal dusts containing carbon. In addition, this effort involved monitoring a research contract with the University of Minnesota and supporting in-kind participation in the Canadian Diesel Emissions Evaluation Project.

Impact:
Research involving diesel-powered equipment determined that; (1) EC was the proper surrogate and (2) the SKC DPM Sampler was the correct sampling method for measurement of DPM concentrations in underground metal/nonmetal mines and many surface occupations. This work directly led to a 2005 revision of the MSHA diesel rule, originally promulgated in 2001. Without NIOSH research, DPM compliance samples, using TC as the compliance surrogate, would be challenged in court. This would result in the continuance of miners being exposed to excessive levels of DPM. Work continues in a succeeding project to; (1) validate the metal compliance method for coal mines, (2) examine methods by which the non quantitative sampling of OC by tissue-quartz can be overcome, and (3) develop a near-real-time DPM personal exposure monitor. Ancillary project work with the

Canadian Diesel Emissions Evaluation Program became the foundation for isolated zone studies of diesel emissions controls.

Assessment of Personal Particulate Exposure

Project Period:
1998 - 2006

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Abstract:
This work investigates fundamental dust measurement technologies for application in mining. Assessment of particulate in mines is currently time-consuming and expensive. New tools and approaches for monitoring respirable dust are required to provide workers with timely feedback of dust exposures, enabling action to protect worker health. The project is developing near real-time quantitative and qualitative mass and pressure-based sensors for coal mine use. Basic research tasks also investigate diesel particulate matter measurements that are based on light-scattering angular ratios, ion trap, and differential pressure technologies. Much of this work is being conducted in partnership with industry and academia. The successful outcome of the work will result in several new tools and approaches to particulate monitoring in mining that ultimately will provide additional protection for worker health.

Impact:
The PDM is commercially available; the manufacturer is presently taking orders. It was recipient of a 2004 R&D 100 award from R&D Magazine, honoring the PDM as one of the top 100 technical developments of the year. This device is supported through a partnership with the United Mine Workers of America, the Bituminous Coal Operators Association, and the National Coal Association. In addition to widespread interest throughout the U.S. mining industry, the PDM has generated attention in both Australia and South Africa.

Imaging and Grading Occupational Disease or Injury

Project Period:
2001 - 2003

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Abstract:
This project researched advanced imaging methods for early in vivo detection of lung fibrosis diseases, e.g., silicosis or asbestosis, using (1) positron emission tomography (PET) and (2) magnetic resonance imaging (MRI). PET imaging identified areas in the lungs of heightened metabolism associated with collagen biosynthesis in fibrosis, using a novel tracer for the localized uptake of a proline amino acid analogue, an early event in scar tissue formation. In collaboration with the West Virginia University PET Center, rabbits were imaged at intervals over a five month period after they had been challenged with silica dust. Tests were successful and published in the Journal of Nuclear Medicine. A capability for magnetic resonance imaging (MRI) was set up in NIOSH for research

and support to other projects using animal model studies. Preliminary MRI imaging was performed on a rat model in preparation for studies of non-invasive detection and evaluation of occupationally-related injury.

Impact:
Potential applications of a fully tested method include surveillance of public or workforce exposed to respirable materials of uncertain risk, e.g., first responders to calamitous events such as the World Trade Centers disaster, and improved surveillance of workers in dusty trades, e.g., mining or construction. Researchers from Cambridge University, England, Imperial College, England, and Zentrumforschung Julich, Germany, in a letter to the editor (J Nuc Med 44:483-4, 2003) stated their unpublished and abstract-reported studies were generally consistent with the NIOSH results; and they suggested considerable potential for the method to monitor scarring and its possible use with patients.

Biomonitoring Analyses for Studies of Dermal Exposures

Project Period:
2000 - 2006

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Abstract:
NIOSH has estimated that 42 percent of the U.S. workforce is at risk of dermal exposure to hazardous chemicals. Biomonitoring Analyses for Studies of Dermal Exposures (BADE) project researchers evaluate biomarkers to determine the exposure, and effect of exposure, of occupational agents such as jet fuel, industrial solvents, motor oils, and acrylamide. Workers in transportation, chemical, manufacturing, mining, and construction industries are potentially exposed dermally to these occupational agents, which are associated with increased risks for systemic toxicity and cancer. Following method development and field validation, project researchers transfer the technology for occupational exposure assessment. Exposure data are essential to the goal of reducing occupational disease. The biomonitoring data will help to determine intervention use and effectiveness, substance-specific exposure for epidemiologic studies and quantitative risk assessments, standard recommendations, and compliance. Four published articles and two articles in press are products of the project. Seventeen presentations have been given at scientific meetings.

Impact:
This project develops methods for measuring chemicals and provides biomonitoring analysis to field investigations of chemicals that are expected to be dermally absorbed. This approach has been incorporated into several studies. The first was the JP-8 jet fuel study, and our data disclosed significant systemic exposures among flight line workers. Recently scientists have had discussions with the USAF regarding additional studies to access worker exposures to JP-8 jet fuel, specifically to evaluate the efficacy of changes that have been made regarding worker protective clothing. The second study of note was on 1-bromopropane. Human metabolites have been identified and toxicokinetic monitoring was conducted to validate the most useful exposure biomarker. A metabolic profile for 1-bromopropane was included in the NIOSH Draft Current Intelligence Bulletin. Analytical results on >700 field samples have been reported, and the possibility of an intervention study was suggested for the sites of greatest exposure levels.

Evaluation of LIF Technology for Bioaerosol Screening

Project Period:
1997 - 2000

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Abstract:
This project examined the applicability of emerging transportable laser-induced fluorescence technology as a screening tool for identifying airborne microorganisms in workplaces by applying technologies developed by the Department of Defense to detect bioaerosols. The number of reported indoor air problems is rapidly increasing and includes such problems as irritation and immunologic and infectious diseases. A need exists to develop real-time monitors that identify airborne microorganisms in workplaces. Airborne microorganisms are suspected of causing illness in (sick(buildings, worksites using contaminated metal working fluids, some agricultural exposure situations and health care patient rooms. Success in this project helped in the development of transportable devices to be used for identifying problematic airborne microorganism in workplaces.

Impact:
Several field-portable instruments based on the fluorescence spectral method have been developed under collaborations among the Army Research Laboratory, Yale University, Naval Research Laboratory, and MIT Lincoln Laboratory. They have been used for atmospheric monitoring and field surveys.

Evaluation of New Technologies for Bioaerosol Screening

Project Period:
2000 - 2002

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Abstract:
This is a follow-on project of the laser-induced fluorescence (LIF) project 8968, which examined the feasibility of using LIF technology as an approach to detecting microbes in real time. Although a LIF device can detect microorganisms of high concentrations, the device requires further improvement in reducing the spectral interference contributed by the non-microbial organic dust, such as cigarette smoke, as well as in enhancing its sensitivity before it can be applied to an indoor problematic environment with low airborne microbes. More importantly, the high cost of a LIF system in the present format would make the technology impractical to be adopted for workplace application. It is, therefore, essential to redirect our efforts with a broader focus on other new technologies, such as polymerase chain reactions (PCR), mass spectrometry (MS), and Fourier Transform Infrared (FTIR) spectroscopy. Our results indicated that PCR is the most suitable method available for development as a field device.

Impact:
A microbiological assay system has been established in the laboratory which has the potential to become a screening tool to detect total airborne fungi in the environment.

Use of PCR Technology for Detecting Airborne Microorganisms

Project Period:
2002 - 2003

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Abstract:
Many health effects experienced by workers are traced back to their exposure to bioaerosol in the workplace. Sampling at selected locations may miss the problem area and consume extensive time. The urgent need for a near-real-time field-transportable bioaerosol sensor has not been fulfilled. Based on the results from the project entitled, Evaluation of New Technologies for Bioaerosol Screening, the technology of using PCR has stood out and demonstrated its special features of low detection limit (1-2 cells), fast and quantitative measurements, and field portability and thus serves as a potential screening tool for this need. In addition, this technology could permit the identification of specific species as well as total microbial contents. This follow-on project will investigate potential effects of dust on this technique and develop a sampling and analysis system that is suitable for industrial hygienists to conduct field survey.

Impact:
All workers will benefit from such a device for quickly identifying a potential problem and even locating the source of bioaerosol in their work environments. This is particularly important considering the specific clusters of hypersensitivity pneumonitis among metal working fluid-exposed workers in the automobile industry, the large number of agricultural workers exposed to organic dust, the increased occurrences of sick building syndrome in indoor office environments, the potential hazards to healthcare workers due to unavoidable contacts with patients having infectious diseases, the outbreak of acute pulmonary hemorrhage among infants who reside in water-damaged houses, and the potential occupational exposure in biogenetic industry which is involved with rapid development of genetically engineered biological species.

Particle Surface Program: Dust Characterization

Project Period:
2001 - 2004

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Abstract:
The researchers involved in this project performed analyses of particle surface composition and structure in conjunction with the projects, Particle Surface Program: Chemistry Characterization and Particle Surface Program: Biological Interactions which study particle surface chemistry and toxicology. Together, these comprise the program-project "Respirable Particle Toxicity and Surface Properties", The overall purpose of the program-project is to identify surface properties and interactions controlling respirable particle expression of toxicity. Previously developed surface analysis methods are being applied to determine the surface elemental composition of respirable particles. Without this knowledge, current methods of exposure assessment may under-or over-estimate the true hazard of an exposure. Analysis of mineral dust samples from Chinese metal mines and pottery workplaces, US Coal Mines, and South African gold mines are being performed to determine the relationship between surface-available silica and lung fibrosis risk. Additional studies of dusts supplied from various sources will be performed, including more silica exposures, as well as welding fume and hard metal exposures.

Impact:
The results of our research have generated invitations to workshops and seminars including:

- Third International Workshop on Environmental Monitoring and Silica Dust Exposure Assessment" to be held in Wuhan and Yichang, People's Republic of China, April 15-18, 2005;
- National Toxicology Program, National Science Foundation, US EPA, US Airforce Office of Scientific Research: "National Nanotoxicology Workshop - Developing approaches for evaluation of toxicological interactions of nanoscale materials". Invited participant. U. Florida, Nov 3-4, 2004;
- US National Institute of Standards and Technology (NIST) / The American Ceramic Society - Crystalline Silica Workshop 2002. Invited Tutorial: "Surface of

silica particles: surface properties and some toxicological and epidemiological anomalies". Gaithersburg, MD. 2002; and

- 3rd International Symposium on Silica, Silicosis, Cancer and Other Diseases . Invited Tutorial "Surface composition and the role of surfactant". Pre-Symposium Mini-Course: Silica Pathology, Carcinogenicity and surface Chemistry". Santa Margherita, Italy, 2002.

Antineoplastic Drug Exposure: Effectiveness of Guidelines

Project Period:
2001 - 2005

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Abstract:
The antineoplastic drug study examines all areas of exposure in detail, such as environment, internal absorption, genotoxicity markers, work practices, and administrative and engineering controls to determine which measurements best reflect exposure and internal dose. Each area provides information on exposure, but no one area has shown to be sufficient in evaluating the total exposure. The genotoxicity markers included in this study were carefully chosen based on the knowledge of the actions of the drugs. These markers can be utilized to evaluate exposure to multiple drugs and they have previously been used in studies which evaluated antineoplastic drug exposure. The findings of this study may indicate that genotoxicity markers are suitable to measure the integrated exposure to antineoplastic drugs. This finding alone would be most helpful in the occupational setting because air levels, surface contamination and urinary levels of these drugs currently measure only a few specific drugs.

Impact:
Because the main study has not occurred, no direct impacts can be reported. However, methods development has led to a study that resulted in a published report in the literature. The latter study documented the external contamination of antineoplastic drug vials with the drug contained in the vial. Since this is one of several sources of potential exposure to antineoplastic drugs in the workplace, it is a crucial part of the main study. The publication of the article, along with two companion studies, prompted an editorial in the pharmacy journal where the article was published. This editorial called for the drug manufacturers to reduce the external contamination of the vials, thus eliminating one potential source of exposure for healthcare workers. A MedWatch form was filed with the FDA concerning the results of this study. This prompted the FDA to contact drug manufacturers to review their manufacturing processes.

Immunochemical Methods for Biomarkers: Exposure and Effect (Dry Cleaning)

Project Period:
1996 - 1997

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n/a

Abstract:
In this project a battery of biomarkers was developed to characterize the continuum between occupational exposure to perchloroethylene (PCE) and disease. Originally, this project was to investigate the development of rapid immunochemical assays for detecting various metabolites of PCE and trichloroethylene (TCE) in urine and to investigate whether measurement of urinary levels of biomarkers of exposure and effect

are more appropriate measures of potential exposure-related disease in workers than biomarkers of exposure alone. Because PCE and TCE metabolites in urine proved to be poor immunogens, exposure monitoring by immunochemical means was not pursued. Instead, the worker population was used as a pilot study to determine the usefulness of measurement of glutathione transferase in blood or urine to assess liver or kidney damage, respectively. Results of this project were used to evaluate the suitability of these assays for future NIOSH field studies.

Impact:
This research provided important information on the usefulness of rapid, organ-specific measures of toxicity. These assays are sensitive, rapid, and can identify harmful effects within a few hours of exposure. Because regular environmental sampling may not identify worker exposures that are harmful, simple rapid indicators of early injury could provide both an increased level of protection for exposed workers and rapid assessment of controls and workplace practices that are put in place to decrease exposures.

Biological Monitoring Research and Support

Project Period:
1980 - 2005

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Key Partner(s):
NCEH

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Co-Investigator(s):
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Cynthia Striley, PhD
NIOSH

Abstract:
Exposure to potentially harmful chemicals can occur in the workplace and also from ubiquitous environmental sources. While the ideal situation is no exposure, to minimize potential health effects, safe exposure limits are developed based on the best available science. Animal and human epidemiological studies are regularly used to derive safe limits, but often knowledge gaps exist that require the use of uncertainty factors to account for intra-species and individual human sensitivities. Under this project, new biological monitoring analytical methods are developed and biological monitoring analyses are provided for Institute field investigations. Biological monitoring results are used to demonstrate the existence of an exposure problem, so that it can be corrected, and the adequacy of control technologies and intervention strategies.

Impact:
This work has resulted in the publication of four journal articles that have been cited over 40 times. EPA has used the data from this work to re-evaluate uncertainty factors used in risk assessments and have applied them to new risk assessments for trichloroethylene (revised RFC and RFD) and chloroform (RFC). The development of expedient and cost-effective, high-throughput methods is having great impact on the direction of occupational exposure research throughout the institute. Because of decreases in cost per assay, low sample volume requirements and faster turnaround, field studies can be designed to better assess chemical exposures. For example, to conduct conventional analysis of trichloropyridinol (a pesticide metabolite) in urine requires extensive sample preparation and expensive analytical equipment ($10,000/100 samples/10 days). In contrast, using the method developed in this project requires simple dilution of the sample and an inexpensive reader ($500/100 samples/8 hours).

Application of Biomarkers to Human Field Studies

Project Period:
1994 - 1998

Researcher Name:
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Key Partner(s):
NCI

Indian Institute for Occupational Health

EPA

Co-Investigator(s):
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NIOSH

Kenneth Cheever
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Dwight Werren
NIOSH

Abstract:
During the five-year duration of this project, five biomarkers of exposure and nine susceptibility markers were developed or implemented in our laboratories in support of field study efforts. The agents of interest have been varied, but include methylene bis-2-chloroaniline (MOCA), benzidine, paving asphalt, nitrosamines, and Histoplasma capsulatum. Collaborative efforts have included other NIOSH Divisions, NCI, CDC, EPA and the Indian Institute for Occupational Health. Ten biomarkers have been developed and field tested as part of this project resulting in six publications, seven presentations, and one provisional patent. One paper was a finalist for the 1997 CDC Shepard Award. The provisional patent was awarded for A PCR method to detect Histoplasma capsulatum in soil.

Impact:
This was a methods development project. Ten methods were developed or implemented into the laboratory. One manuscript published from the results of this project was a 1997 CDC Shepard Award finalist. The PCR method to detect Histoplasma capsulatum was granted a provisional patent. This method provides a faster, easier, more cost effective, and less time-consuming way to determine if soil is contaminated with H. capsulatum. This method is a potential breakthrough for the construction and agricultural industries in that sites will be able to be tested for contamination and the results known within two days as opposed to the two months by the standard method easing the economic burden caused by the delay in testing for contamination. The research conducted on MOCA was used by the International Agency for Research on Cancer to change their carcinogen rating of MOCA from a class 2B to a class 2A carcinogen.

Predicting Skin Penetration: Model and Experiments

Project Period:
2001 - 2006

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Key Partner(s):
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Wright State University

Co-Investigator(s):
Ana M. Barbero
NIOSH

Abstract:
The long-term objective of this project is to improve the ability of mathematical/computer modeling to predict both steady- and non steady-state penetration of chemicals through human skin. The underlying hypothesis is that dermal penetration can most appropriately be predicted using a "random walk" approach. This model is unique in that it proceeds from first principles (diffusion) and explicitly accounts for the heterogeneous structural properties of stratum corneum (SC), which govern skin permeation. Diffusion is modeled at the micro level as a random walk, from which macro-level diffusion properties, including permeability, can be derived. In-vitro penetration and diffusion studies will be performed using excised human cadaver skin. These results will be used for parameter optimization of the computer model and to evaluate the predictive ability of the model.

Impact:
This project is playing an active role in advancing the fund of knowledge regarding an area under active research—the investigation of dermal penetration of workplace chemicals. This is basic research, and is not yet mature enough to have instigated practice-centered interventions. This research has been cited by others in the peer-review literature and has been favorably received by the scientific community. Our analysis of the sources of data analyzed with quantitative structure-skin permeability relationships methods has prompted researchers to alter the data base upon which their dermal permeation estimation algorithms are based.

Modeling Exposure Assessment Systems

Project Period:
1996 - 1997

Researcher Name:
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NIOSH

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Key Partner(s):
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Co-Investigator(s):
n/a

Abstract:
Assessing the hazard of breathing many airborne particles requires collecting the material on a filter for analysis. For some materials, it is necessary to collect particles as large as 100 μm. The design and wind-tunnel testing of such samplers to determine their sampling characteristics is complex and expensive. The approach of this work was to apply relatively new tools of computational fluid dynamics to numerically

estimate the performance of the early "button sampler" using a simplified two-dimensional model. Particle trajectories were calculated in a variety of wind velocities. The results explained a variety of characteristics of this style of sampler and suggested some ways to improve them. This work demonstrated that valuable insights could be obtained into sampler design through modeling. Later work in other projects has continued to improve the application of computational fluid dynamics as a sampler design tool.

Impact:
This work showed the capabilities and limitations of the existing computational fluid dynamic tools. It demonstrated that valuable insights could be obtained into sampler design through modeling. Later work in NIOSH (CAN 7376) used more sophisticated modeling tools to explore air sampler characteristics.

Development and Evaluation of a Portable GC/MS Unit

Project Period:
1998 - 2000

Researcher Name:
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NIOSH

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Key Partner(s):
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OS/OPHS/OCCFM

Co-Investigator(s):
n/a

Abstract:
In situations such as unknown vapor/gas exposure in workplaces, microbial contamination of buildings, severely contaminated hazardous waste sites, and industrial accidents, the logistics of field monitoring require immediate results to operate safely and efficiently. Under conditions where exposure agents are unknown, a portable GC/MS would offer an acceptable means of carrying out on-site analyses because of its sensitivity and versatility in identifying unknown chemicals. This project is designed to evaluate the newly redesigned, field- deployable GC/MS unit by DART (re-engineered using an old model of Viking instrument) and continue its improvement for field applications. The specific aim of this project was to enable field industrial hygienists to rapidly determine microbial volatile organic compounds (MVOCs) as an indicator of microbiological contamination and chemical constituents of complex mixtures of vapors and gases. Concentrations of specific vapors in complex mixtures as a function of time and location can also be measured.

Impact:
This project identified that weight, size, and power restrictions of the field-deployable GC/MS unit needed to be improved. INFICON took into account the limitations recognized in this study in the design of their portable GC/MS. The MVOC profiles established in this project were used by INFICON in evaluating the reliability of its portable GC/MS unit for indoor air quality investigation. (http://www.inficonchemical-warfaredetectionsystems.com/pdf/microbialvocs.pdf)

Estimation of Exposure to Oxidized Terpene Products

Project Period:
2003 - 2006

Researcher Name:
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Key Partner(s):
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Carnegie-Mellon University

Co-Investigator(s):
Ham, Jason
NIOSH

Abstract:
Terpenes are naturally occurring chemicals generally considered to be of low toxicity. They have good solvation properties and are often used in industry as a replacement for more toxic hydrocarbons. They are also found in home and office cleaning products where their fresh pine and citrus scents make them attractive to the consumer. However, oxidation products may be strong lung airways irritants, possibly implicated in COPD and asthma. Oxidation of terpenes can occur through reaction with ozone, or with hydroxyl or nitrate radicals. Indoor ozone levels can rise alongside outdoor ozone concentrations when natural ventilation is used. This research aims to assist assessment of disease risk by assessing exposures. Specific aims included preparing standard oxidized terpene products, developing methods for exposure assessment, characterizing reaction chemistry and product formation, and assessing the potential for exposure in actual workplaces. Research was transferred to the project entitled, Gas Phase Chemistry of Indoor Environments, in 2004.

Impact:
It is anticipated that this research will be of use in the investigation into the rise in inner-city asthma rates seen over recent years.

Evaluation of Samplers with Field Analysis for Lead

Project Period:
2003 - 2005

Researcher Name:
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Key Partner(s):
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OSHA Salt Lake Technical Center

Rose, Mike
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Andrew, Michael
NIOSH

Bartley, David
Consultant

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Lawryk, Nicholas
NIOSH

Pacolay, Bruce
NIOSH

Abstract:
Portable X-ray fluorescence analysis promises on-site analysis of air sampling filters, and therefore more rapid response to employee overexposures. It may also be used for compliance purposes, allowing OSHA inspectors to make on-the-spot citations, provided the technique is sufficiently accurate. Since the technology "reads" the filter, the presentation of the filter deposit may be important for accurate readings, and different samplers provide different dust distributions across the filter. This study has included taking personal and area samples in a variety of workplaces where lead is encountered in aerosol, using a variety of different sampling heads. Each sample was presented to the XRF analyzer and then submitted for routine wet chemical analysis for confirmation. In addition, the insides of sampling heads were wiped and the wipes analyzed to assess sampler wall-losses. The study is due to be completed in September, 2004, but some results are already in publication.

Impact:
This project has had an impact on other NIOSH activities. It has provided field samples that were also used in the project, Portable Analysis of Multiple Airborne Metals (Mining). It has provided information showing that NIOSH Manual of Analytical Methods method number 7702 a) can be improved by substituting the OSHA calibration algorithm, b) can be extended to include at least the GSP sampler, and c) can achieve results acceptable for compliance purposes in the field. This project will have an impact on OSHA activities. It has demonstrated a gap in our ability to determine method accuracy through field demonstration that is being addressed. It has provided data showing that the OSHA version of the XRF method can achieve standards required of compliance methods. This will allow OSHA inspectors to achieve their wish of being able to make citations in the field. Worker health will be improved by more rapid remediation of over-exposure problems.

Particle Surface program: Chemistry Characterization

Project Period:
2001 - 2004

Researcher Name:
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Co-Investigator(s):
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NIOSH

William Chisholm, Ph. D.
NIOSH

Joel Harrison, BS
NIOSH

Madalina Chirila, Ph.D.
NIOSH

Abstract:
This project performs surface chemistry studies in the program-project "Respirable Particle Toxicity and Surface Properties" with two integrated projects (Particle Surface Program: Dust Characterization and Particle Surface Program Biological Interactions) which study respirable particle surface composition and structure, and particulate toxicity. The program is to identify surface properties and interactions controlling respirable particle expression of toxicity. This project is researching particle surface functional groups and their interactions which may control respirable dust toxicity using spectroscopic methods. Principal studies report the (1) chemistry and molecular interactions of components of lung surfactant with respirable silica and kaolin dusts, and (2) radical species generation responsible for hard metal toxicity. This project is a continuation of VAG8971.

Impact:
Information from these studies has been solicited as: (1) an invited tutorial: "Surface of silica particles: surface properties and some toxicological and epidemiological anomalies", 2002; (2) an invited tutorial: "Surface composition and the role of surfactant," 2005; (3) invited participation in: National Toxicology Program, National Science Foundation, US EPA, US Airforce Office of Scientific Research: "National Nanotoxicology Workshop - Developing approaches for evaluation of toxicological interactions of nanoscale materials", 2004; (4) membership in the US Agency for Toxic Substances and Disease Registry (ATSDR): "Expert panel on health effects of asbestos and synthetic vitreous fibers: the influence of fiber length"– in the World Trade Center disaster, 2002; and (5) membership in the National Toxicology Program expert panel review of the potential carcinogenicity of hard metal dusts, 2005.

Field Evaluation of the NIOSH Local Positioning System

Project Period:
1998 - 2004

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Sid Soderholm
NIOSH

Ramesh Gali
NIOSH & West Virginia University

Abstract:
The goal of this project was to prove the Local Positioning System (LPS) can be used with appropriate environmental sensors in outdoor workplaces to assess occupational safety and health hazards by field-testing the unit. The LPS was evaluated in conjunction with a multiple-gas monitor, a sound-level meter, a PID, and a heat stress monitor to assess the exposures and the time and location of those exposures. The telemetry function of the LPS was tested and software was refined, allowing the safety and health professional to determine when, where and how much a worker is exposed to a potential hazard. This will be useful in identifying locations with high exposures, assigning average exposures to tasks performed in a defined area, and assessing exposure variability. The LPS identifies exposure "hot spots" and helps target interventions to reduce employee exposures. The goal of this project is technology transfer to the public.

Impact:
Linking worker location to exposure data from real-time monitors, the Local Positioning System (LPS) identifies and documents where to focus exposure control efforts. LPS data enables safety and health personnel to map exposure intensity and location, reveal hot spots, and provide exposure intensity distributions. Focused exposure control efforts should reduce occupational injury and disease. This capability does not exist elsewhere. The LPS has impacted the decisions of occupational health and safety workers in the construction industry, the US Coast Guard, and the Department of the Interior, National Park Service. In all three work places the LPS identified "hot spots" of exposure and facilitated the reduction of worker exposures. NIOSH has applied for a patent and has announced the LPS as available for licensing in the Federal Register. Many inquiries have been received from the public and from industries interested in using the LPS to evaluate their workplaces.

Analysis Of Workplace Air Samples By Immunoassay Technology

Project Period:
1995 - 1997

Researcher Name:
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NIOSH

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Key Partner(s):
n/a

Co-Investigator(s):
n/a

Abstract:
To address the need for rapid air sampling and analytical methods for pesticides, commercially available enzyme-linked immunosorbent assay methods were investigated.

Since there was no method for alachlor in the NIOSH Manual of Analytical Methods, this was selected as a good compound to test this methodology for air sampling. The commercial kit for alachlor analysis was successfully adapted to an air sampling method using a commercial filter/sorbent combination. The method was evaluated over the range of 0.24 µg to 120 µg per sample, but sample precision was not statistically poolable over the entire range studied. At the 12-, 24-, and 48-µg range, the overall precision was 0.0783, with an accuracy estimate of ±17.4%. The average recovery of all levels was 100%, and samples were stable for at least 7 days at ambient temperature and 30 days when refrigerated.

Impact:
The ELISA-based method developed for alachlor in air filled a gap in the NIOSH Manual of Analytical Methods, since no method for this compound existed. It also extended the application of ELISA based methods beyond the usual liquid matrix of water and body fluids.

A Method for the Sampling and Analysis of Indoor Air for Organic Compounds

Project Period:
1995 - 1999

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Co-Investigator(s):
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NIOSH
Yvonne T. Gagnon
NIOSH
Paula F. O'Connor
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Abstract:
NIOSH researchers have conducted over 1000 Health Hazard Evaluations (HHE) dealing with indoor environment quality (IEQ). IEQ requests for Health Hazard Evaluations comprise 40% of the HHE program. In these evaluations, potential of exposure to volatile organic compounds (VOCs) was a recurring question. This project provided a sensitive and selective method for the detection and identification of VOCs in the workplace. The method used thermal desorption sorbent tube samplers combined with gas chromatography/mass spectrometry for analysis. This method has been included in the NIOSH Manual of Analytical Methods as Method No. 2549, Volatile Organic Compounds (Screening).

Impact:
Since the development of Method No.2549, Volatile Organic Compounds (Screening) and publication in the NIOSH Manual of Analytical Methods, the method has been used in approximately 50 NIOSH industrial hygiene field surveys a year for the past 7 years. The method has become a primary tool for the characterization of occupational exposures to volatile organic compounds in the NIOSH Health Hazard Evaluation Program and in other NIOSH field research studies. The method provided a means to measure worker exposure at levels up to 1000 fold lower than possible by typical analytical methods.

Analytical Research and Development Infrastructure

Project Period:
1998 - 2009

Researcher Name:
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Co-Investigator(s):
n/a

Abstract:
This project provides updated analytical instrumentation and information for Branch chemists to use. New technologies are evaluated for potential use in sampling and analytical method development. Outdated equipment is replaced with new instrumentation. Existing equipment is updated and/or repaired.

Impact:
The equipment purchased with this project has contributed to the development of methods for organometallic compounds by LC/ICP and for herbicides by microbore liquid chromatography and metalworking fluids by LC/MS.

Analytical Microbiology

Project Period:
1993 - 2000

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No longer with NIOSH
Miriam K. Lonon, Ph.D.
No longer with NIOSH

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Co-Investigator(s):
n/a

Abstract:
Millions of workers in manufacturing (e.g., metalworking) and agricultural (e.g., crop and animal production) occupations are potentially exposed to microbiological contaminants. Under this project, researchers developed analytical methods to characterize and monitor such workplace exposures, with metalworking fluids as the primary focus. Airborne microbes and their byproducts (e.g., endotoxin, a toxic component of the Gram-negative bacterial cell membrane) may contribute to inflammatory lung disease. Specific methods included quantitation of endotoxin, cellular phospholipids to characterize microbial ecology, and phosphate derived from cellular phospholipids as an indicator of microbial biomass. Use of the developed methods provides researchers with exposure data needed to choose and assess interventions, interpret epidemiologic studies, develop quantitative risk assessments, assess feasibility of standards, and monitor compliance. Understanding metalworking fluid microbial ecology may form the basis for better methods to control and reduce workplace exposures.

Impact:
Both lead researchers contributed to the NIOSH criteria for a recommended standard for occupational exposure to metalworking fluids. One researcher published a bioaerosol sampling method in the NIOSH Manual of Analytical Methods and coauthored a chapter in an American Industrial Hygiene Association field guide for the determination of biological contaminants in environmental samples. The other chaired an ASTM task group responsible for writing a standard method for the determination of endotoxin in metalworking fluid aerosols that was adopted as a provisional practice. It served as the forerunner of the current ASTM International E2144-01 Standard Practice for Personal Sampling and Analysis of Endotoxin in Metalworking Fluid Aerosols in Workplace Atmospheres.

Portable Mass Spectrometer Evaluation

Project Period:
1995 - 1998

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Saturday Knight Ltd
Aaron B. Rourke
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Co-Investigator(s):
n/a

Abstract:
The performance of a transportable gas chromatograph/mass spectrometer was evaluated in field industrial hygiene studies. Improvements in performance and reduction in size of the instrument were key outcomes. Effectiveness and improvements in worker exposure controls were assessed in a vinyl printing operation, using the GC/MS for control development and assessment. Control development was directed at the reduction of organic solvent emissions from the printing operation, and the recovery of solvents from the workplace for disposal or reuse.

Impact:
A commercial transportable gas chromatograph/mass spectrometer (GC/MS) was evaluated for industrial hygiene applications and was improved by reduction in size and weight. This instrument brings laboratory capabilities in the identification and quantitation of toxic substances to field locations. The NIOSH redesigned GC/MS was used in field industrial hygiene studies to help determine how it might fit into an industrial hygiene field monitoring strategy. Initial laboratory and field studies have confirmed the utility of a portable GC/MS in applications where complex mixtures of gases and vapors are present in the workplace, and where the concentration and identification of specific compounds are required. It is anticipated that industrial hygienists inside and outside of NIOSH will find this instrument useful in many situations. The ability of direct-reading instruments to monitor hazards, demonstrate the effectiveness of engineering controls and personal protective equipment, and to quantify and identify hazardous chemicals is of the utmost importance.

Analysis of Silica Polymorphs

Project Period:
1997 - 2003

Researcher Name:
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OSHA

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Co-Investigator(s):
n/a

Abstract:
Occupational exposure to crystalline silica can lead to silicosis, a debilitating and often fatal lung disease, and has been linked to lung cancer, kidney disease, and other disorders. From pottery to mining to construction, it has become well-known: "if it's silica, it's not just dust." To facilitate effective silicosis surveillance and intervention, barriers to precise exposure assessment were identified and addressed.

Impact:
OSHA Directorate of Standards has included language addressing quality assurance protocols in the preamble of the current draft silica standard. All government analytical methods have been harmonized and peer reviewed, with each area of silica analysis now having a validated analytical method. Required NIST-certified standard reference materials (SRMs) are now on the market, including 2 reissued SRMs and 3 newly-developed SRMs. Additional work was completed to insure continued availability of these products.

Analysis of Silica Polymorphs

Project Period:
2003 - 2006

Researcher Name:
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Marilyn Fingerhut
NIOSH

Co-Investigator(s):
n/a

Abstract:
Occupational exposure to crystalline silica can lead to silicosis, a debilitating and often fatal lung disease, and has been linked to lung cancer, kidney disease, and other disorders. From pottery to mining to construction, it has become well-known: "if it's silica, it's not just dust." Factors which have been shown to be crucial to accurate and precise exposure assessments need to be disseminated via accessible mechanisms such as consensus standards throughout the silica community and among developing countries.

Impact:
Several countries are following the lead of the NIOSH work. South Africa is currently assessing laboratory performance for silica analyses, and Italy is planning a European symposium patterned after the ASTM symposium to address analytical issues in exposure assessment for crystalline silica. U.S. industry is actively participating in the consensus guidelines work through ASTM. Collaboration and cooperation have reached a global status with participation of industry, academia and government toward a common goal of accurate exposure assessment.

Development of a Portable XRF Unit for Air Sample Screening

Project Period:
2000 - 2005

Researcher Name:
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ATSDR

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NIOSH
Paul Pierce
NIOSH

Co-Investigator(s):
n/a

Abstract:
Millions of workers are employed in the construction industry in occupations where significant amounts of airborne toxic metals are generated. Depending on the work practices, processes, techniques, and locations, workers may be exposed to airborne concentrations of a wide variety of metals which may have toxic effects. The main purpose of this project was to evaluate portable x-ray fluorescence (XRF) as a screening tool to aid in the prevention of worker overexposures to metals in the construction and mining industries. The existing method was evaluated in mining, recycling, and other processes. An emerging XRF technology was identified and characterized. These findings will be used to expand existing NIOSH XRF methodology for on-site assessment of metal exposures and the protection of the health of workers.

Impact:
Roundtable sessions held at the American Industrial Hygiene Conference and Exhibition in 2002 and 2004 detailed the state of the science and future directions of field-portable methods for on-site assessment of worker exposures to metals. These sessions were heavily attended, and triggered numerous additional publications and invited presentations at other conferences.

Portable Instruments for Measuring Airborne Metals

Project Period:
2000 - 2005

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Aaron Sussell
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Paul Pierce
NIOSH

Co-Investigator(s):
n/a

Abstract:
Millions of workers are employed in mining, construction, and other workplaces where the toxic effects of airborne metals may be realized. This program project sought out, characterized, and evaluated screening and analytical tools to aid in the prevention of overexposures to airborne metals associated with adverse health effects. Existing NIOSH methods for portable measurement of airborne lead were evaluated in mining, recycling, and other operations. Emerging technologies for on-site screening and measurement were identified and characterized. Methods for hexavalent chromium and other metals were evaluated using workplace samples. Awareness of NIOSH methods for portable measurement of airborne metals along with their usefulness, and perceived barriers to their use were identified among industrial hygiene and occupational safety professionals. Recommendations were developed on how to optimize awareness, acceptance, and use of NIOSH methods for portable technologies to assess metal exposures and protect the health of workers.

Impact:
Roundtable sessions held at the American Industrial Hygiene Conference and Exhibition in 2002 and 2004 detailed the state of the science and future directions of field-portable methods for on-site assessment of worker exposures to metals. These sessions were very well-received. Both sessions triggered numerous additional publications and presentations. The hexavalent chromium field method was fully adopted by the U.S. Air Force for field-based monitoring of hexavalent chromium during maintenance and repair of aircraft. Aspects of the field methods for the measurement of lead and hexavalent chromium were incorporated into international voluntary consensus standards (ASTM and ISO). A patented field screening technique for detecting lead in surface dust wipe samples was licensed and is being marketed commercially.

Analytical Methods for Organic Compounds

Project Period:
1983 - 2001

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Sunset Laboratories

Co-Investigator(s):
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Robert A. Glaser
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Abstract:
Millions of workers in manufacturing, construction, and mining are potentially exposed to complex mixtures containing hazardous substances, with increased risks for respiratory diseases and cancer. Under this project, researchers developed analytical methods to characterize occupational exposures to asphalt fume, aerosols of metalworking fluids, and diesel exhaust particulates. The methods were applied to identify and quantify hazardous substances in samples of metalworking fluids and asphalt fume and in the field to quantify worker exposures to metalworking fluid aerosols and to diesel exhaust particulates.

Impact:
Qualitative analytical results generated under this project contributed to the NIOSH hazard review of exposure to asphalt fume and the NIOSH criteria for a recommended standard for occupational exposure to metalworking fluids. Three methods were published in the NMAM. The universal method for metalworking fluids was adopted as a provisional ASTM standard. Its use in field studies documented the feasibility of the NIOSH recommended exposure limit (REL) in small machine shops. The method for monitoring exposure to diesel particulate has enabled adoption of more stringent recommendations by the American Conference of Governmental Industrial Hygienists (ACGIH) and standards by the Mine Safety and Health Administration (MSHA). Follow-on work in subsequent projects led to adoption of the metalworking fluid and diesel exhaust particulate methodologies as ASTM standards (D7049-04 Standard Test Method for Metal Removal Fluid Aerosol in Workplace Atmospheres and D6877-03 Standard Test Method for Monitoring Diesel Particulate Exhaust in the Workplace).

Health Assessment of Workers Exposed to 1-Bromopropane

Project Period:
2000 - 2004

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Abstract:
The purpose of this project was to conduct a health assessment of workers in partnership with exposure assessment studies conducted by DSHEFS. Although the original scope of the health assessment was scaled back to some degree, BHAB was able to successfully collaborate with HETAB on two Health Hazard Evaluations (HHEs) at worksites using

1-bromopropane (1-BP) as a solvent vehicle for spray adhesives. A biomonitoring method to detect 1-BP metabolites in urine was developed and utilized in the HHEs to assess worker exposures. The comet assay was used to assess DNA damage in leukocytes from exposed workers, and exposure to 1-BP was not associated with an increase in DNA damage. These collaborations provided much of the current available data characterizing worker exposures to 1-BP. Poster presentations describing the DNA strand break data and the analytical biomonitoring methods developed as part of this project have been presented at scientific meetings.

Impact:
Assistance was provided to two HHEs and both internal biomarkers of exposure (urinary metabolites) and effect of exposure were determined (comet assay) in exposed workers. The biomarker data obtained in this study provided NIOSH and OSHA with data on exposure and effects of exposure in workers where personal breathing zone and area monitoring data were also obtained on the same groups of workers. These results from workers help to address the lack of human exposure data on 1-BP and will be used to develop occupational exposure standards and to suggest interventions which will minimize adverse effects in workers exposed to 1-BP. Two new validated biomonitoring methods are now available for use in future assessments of worker exposures to 1-BP by NIOSH and other stakeholders.

Biomarker Development for Human Exposure Assessment

Project Period:
1997 - 2004

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Abstract:
Biomarkers have been gaining increasing importance in human exposure assessment. They can provide critical information to relate internal dose with external exposure and aid in our understanding of health risk associated with an exposure. The objective of this project was to develop and validate biomarkers of widely used toxicants for use in exposure assessment for field studies. A wide variety of occupational hazards was investigated over the 6-year history of this project. Studies evaluated biomarkers to detect exposure, effect, or susceptibility of workers to roofing asphalt, perchloroethylene, JP-8 jet fuel, and used motor oil. One additional study, Upper Midwest Health Study, assessed genetic polymorphisms and their relationship to brain cancer incidence. During this project life span, fifteen polymorphism methods were either developed or implemented in our laboratory. Research from this project generated seven manuscripts, one book chapter, and twenty-four presentations.

Impact:
This was a methods development project; therefore, 15 new or improved methods have been added to the laboratory's repertoire. Newly developed methods have been published in the literature. Their direct application to current health and safety issues is limited; however, these newly developed methods should improve future exposure assessments studies. Many of these methods can be used to determine intervention effectiveness.

Evaluation of Methods: PAH Determination in Asphalt Fumes

Project Period:
2003 - 2007

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Abstract:
The High Performance Liquid Chromatography (HPLC) / fluorescence methods used to determine polycyclic aromatic hydrocarbons (PAHs) in asphalt fumes are inappropriate

because the compounds co-elute and the methods provide inadequate identification. This construction project will develop and test methods that reliably identify and quantify PAHs in asphalt fumes. Researchers from the Heritage Research Group and NIOSH will determine PAHs in asphalt fumes with these methods and compare the results against those obtained by gas chromatography/mass spectroscopy (GC/MS) techniques. A reliable sampling and analytical method for identifying and quantifying individual PAHs in asphalt fumes is needed so that correlations can be made between air concentrations and biomarkers used to assess a worker's true exposure. The method(s) developed will cause less reliable methods to fall into disuse. Additionally, once the reliable PAH data are known, risk assessments can be conducted and new standards established.

Impact:
Once reliable sampling and analytical methods are known or developed for identifying and quantifying individual PAHs in asphalt fumes, industrial hygienists and other researchers will know which methods are more reliable and with time the less reliable methods will fall into disuse. Researchers will also be able to establish correlations between air concentrations and biomarkers used to assess a worker's true exposure. In addition, researchers and policymakers will be able to conduct risk assessments and establish new standards using PAH data that they know are more reliable. If PAHs are found to be unacceptably high, future projects may focus on the development of engineering controls, or the production of asphalts that have lower PAH concentrations or have fewer emissions.

Gas and Vapor Monitoring

Project Period:
1999 - 2002

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Co-Investigator(s):
n/a

Abstract:
Workers in dental clinics are sometimes exposed to hazardous levels of nitrous oxide, an anesthetic. An expert panel of the American Dental Association Council on Scientific Affairs reported that the development of equipment to measure and control exposure to nitrous oxide was high priority research. As a first approach, NIOSH attempted to adapt current electrochemical and infrared sensors used to monitor other gases for this purpose. One manufacturer developed a prototype infrared instrument, which NIOSH evaluated and found to be promising. However, the manufacturer's mass-market version of the instrument was not sensitive enough to meet the need. The manufacturer did become aware of the potential occupational safety and health market for gas monitoring instrumentation. Overall, NIOSH showed in this short-term effort that a longer term and more costly research effort would be required before a suitable nitrous oxide monitor could be developed.

Impact:
A company that manufactures gas monitoring instruments became aware of the potential occupational safety and health market. Unfortunately, the company's first attempt to enter that market failed to produce an instrument that was sensitive enough. In total, the NIOSH effort showed that no short-cut exists to a suitable nitrous oxide monitor using technologies currently applied to other gases. A longer-term and more expensive research effort would be needed to develop such a monitor.

Personal Dust Monitoring

Project Period:
1996 - 2000

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Great Britain Health and Safety Executive
Mine Safety and Health Administration
Consolidation Coal Company
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Co-Investigator(s):
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Abstract:
The project investigated fundamental dust measurement technologies applicable to personal dust monitoring in the mine work place. Assessment of respirable dust levels in mines is time consuming and expensive. New tools and approaches to monitoring respirable dust were required to provide timely feedback of miner dust exposures and enable action to

mitigate excessive exposure. The project developed an end-of-shift dust dosimeter based on the correlation of filter pressure restriction with cumulative mass. It is similar to gas detector tubes in that it is inexpensive but accurate enough to warn of overexposure. This development was in partnership with industry and academia. The successful outcome is a new tool and a new approach to dust monitoring in mining. In addition, this program absorbed the responsibility for certifying each new Coal Mine Dust Personal Sampling Unit (CMDPSU), used for personal compliance sampling in underground and surface mining operations.

Impact:
Dosimeter development has been in partnership with the United Mine Workers of America, Great Britain(s Health and Safety Executive, the Mine Safety and Health Administration, Consolidation Coal Company, Jim Walter Resources, the Pennsylvania State University, and the University of Minnesota. A CRADA partner was added to the work for subsequent commercialization of the dosimeter. During this research project, it was found that diesel particulate matter (DPM), or solid engine emissions, greatly increased the response ratio of the filter differential pressure to the mass loading of the dust dosimeter. This work resulted in the development of a new program that concentrated on real-time measurement of DPM being emitted from engines in underground mines. The intent of this project was to build on the inherent disadvantages of the Dust Dosimeter (excessive DPM filter loading) and use the increased response as a way to monitor DPM.

Revision of Methods in NMAM

Project Period:
1998 - 2000

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Abstract:
The NIOSH Manual of Analytical Methods (NMAM) is a source used by OSHA, MSHA, EPA, private sector laboratories and universities, and foreign health agencies. The NMAM, while subject to revisions and the incorporation of supplemental editions over the years, still contains many methods that are technologically outdated (some over 20 years old) and/or problematic, as identified in a recent survey of various client users of the NMAM. Using the results of this survey, fourteen methods were identified and evaluated during this project. The newly developed or modified methods were characterized by significant improvements in the Limits of Detection and Quantitation (LOD/LOQ), analyte recoveries from the sampling media at lower sample concentrations, and improved or newly determined storage stability results. These improvements were achieved by modifications or changes in the desorption solvent(s) and sampling media employed as well as advancements in column technology, instrumentation, and data collection systems.

Impact:
The overall impact of the project was the improvement of the quality and reliability of methods contained in NMAM. The methods developed in this project resulted in more accurate sampling and analytical measurements of occupational health hazard exposures. High quality sampling and analytical methods are necessary to monitor initial exposures in the workplace and for subsequent monitoring of engineering controls to measure the effectiveness in reducing occupational exposures.

Screening of Metalworking Fluids Using LC-MS

Project Period:
2001 - 2004

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Abstract:
Methods were developed to screen metalworking fluids (MWF) for hazardous compounds using mass spectrometry (MS) as the main confirmatory route. MS provides information on molecular formulae and structures, confirming the presence of anticipated compounds and assisting identification of unknown species in the complex matrices of MWF. Some MS analysis was done directly

Impact:
Impact of the study is unknown at present. However, a local major manufacturer of lubricants and coolants has expressed interest in the publication on detection and confirmation of triazine biocide. Recently NIOSH was asked to analyze for biocide content in samples brought back from a DSHEFS field survey of a production facility, where metalworking fluids are extensively used and breathing difficulties have been noted by staff. Application of the triazine biocide method to these samples demonstrated that one set contained very high levels of the compound, despite assumptions by plant management that it was essentially absent from their fluid supply. Analysis of metalworking fluid samples from a separate field survey seems to provide evidence that triethanolamine can convert into diethanolmaine, as the fluid is used; the latter compound is a precursor of the highly carcinogenic N-nitrosodiethanolamine.

The production of species-specific reagents for airborne fungi measurements.

Project Period:
2003 - 2006

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Abstract:
Occupational exposure to fungi and especially fungal spores in office buildings or farm environments have been associated with a variety of adverse allergenic, infectious or toxic health effects. In order to better understand and assess the impact of fungal aerosols on human health, accurate and precise information on the spatial and temporal dynamics of fungal contamination are required. In this project we propose to investigate the potential of a new technique called phage display to produce specific reagents for the detection of fungi and also to assess fungal contamination in indoor environments. This research addresses the need for the development of objective monitoring methods for fungi, and it will help to implement an informed management process in environments with indoor air quality concerns.

Impact:
The preliminary results of this project have contributed to a better understanding of the fundamental diversity and complexity of fungal antigens. They confirm immunological results of widespread cross-reactivity among fungi. They also emphasize that significant basic analytical research is required to identify relevant target proteins. The methods for the identification of specific antigens, as developed in this project, will also be beneficial for other diagnostic techniques such as antibody production. The eventual selection of species-specific reagents and their antigens will allow the development of specific diagnostic tests and facilitate the isolation of species-specific proteins that can then be used to design microarray-based analysis techniques for environmental samples. The proposed methods also provide an informative model for any other bioaerosol including agents of biodefense and bioterrorism. The application of specific monitoring reagents will be essential for the development of a standardized approach and reproducible assessments of bioaerosols.

PA-FTIR Spectroscopy for Crystalline SiO2 Analysis

Project Period:
1998 - 2001

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Co-Investigator(s):
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Abstract:
Occupational over-exposure to respirable quartz dust remains an important hazard, since silicosis and death result too often. Prevention requires timely identification of excessive airborne concentrations of respirable quartz. The approach of this project was to find and demonstrate the utility of an analytical technique as a potential screening method providing a fast,

preliminary filter analysis. A customized Photoacoustic Fourier Transform Infrared (PA-FTIR) accessory was designed. The limit of quantitation for 25 mm filters was comparable to some current analytical methods, but further optimization of the PA-FTIR accessory and method might decrease it even more. Comparisons with standard X-ray diffraction and Infrared methods showed the relative ability of PA-FTIR to detect quartz in the presence of coal mine, brick and cement dust. The approach is promising, but design and evaluation of a PA-FTIR accessory optimized for 25 mm filters is necessary to demonstrate whether this is a suitable screening method.

Impact:
The idea that PA-FTIR may be ideally suited for analyzing filter samples of dusts without any sample preparation had never been explored. The first publication showed that the approach was feasible. It may be applicable to a variety of inorganic and organic dusts. Currently, a manuscript describing the results of the evaluation of the customized PA-FTIR accessory for respirable quartz is in internal review prior to being submitted to a journal. This work produced an incremental increase in knowledge about a promising technology for more timely analysis of air sampling filters containing quartz, but some additional development of the technique is necessary before it can be recommended for widespread use. OSHA has expressed interest in the results, since improvements in the timeliness of obtaining exposure information is expected to contribute significantly to the timely identification of potential overexposure situations.

Use of LC/MS to Identify Isocyanate Exposure Hazards

Project Period:
2000 - 2004

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George Williamson
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Abstract:
Exposure to isocyanates is a major cause of occupational asthma. Isocyanate exposures are frequently complex, and traditional methods have not been capable of accurately measuring all the isocyanate species present. Over the course of this project, NIOSH Method 5525 for total isocyanates was further evaluated and refined. Conversion of the method to a liquid chromatography/mass spectrometry method was explored. The method was used to evaluate isocyanate exposures at truck bedlining facilities and in other health hazard evaluations, and the technology was transferred to the NIOSH contract laboratory. The complementary DAN method for isocyanates was developed, both through funding by the International Isocyanate Institute to collaborators at the University of Massachusetts - Lowell and through intramural research. The DAN method operates by converting complex mixtures of isocyanates into a single analyte for measurement. It has the potential to be a more accurate and less expensive alternative to established total isocyanate methods.

Impact:
The MAP isocyanate method, NIOSH 5525, has been used to investigate isocyanate exposure in the truck bedlining industry. As a result of this investigation, a NIOSH Alert has been drafted. Future assessments in this industry will be used to evaluate the effectiveness of ventilation systems. Additionally, NIOSH 5525 has been used by field researchers in numerous Health Hazard Evaluations. A joint U.S. patent application has been filed by NIOSH and U. Mass. Lowell relating to the DAN isocyanate method. This method is expected to enable total isocyanate analyses that are more accurate and much less expensive than existing methods, making it especially attractive for use by small businesses. This method could improve identification of workers at high risk enabling early intervention, better evaluation of effectiveness of control strategies, and elucidation of the dose-effect relationship in epidemiological studies.

Analytical Method for Total Isocyanate in Air

Project Period:
1990 - 2001

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Abstract:
Exposure to isocyanates is a major cause of occupational asthma. Isocyanate exposures are frequently complex, and traditional methods have not been capable of accurately measuring all the isocyanate species present. In response to this situation, two new methods using novel derivatizing reagents were developed for the sampling and analysis of total isocyanate in air. One of these methods uses the reagent MAP for derivatiziation with pH-gradient liquid chromatography and UV and fluorescence detection for measurement. The other method uses the reagent PAC for derivatization and conversion of all derivatized isocyanates to a single analyte. The two methods are complementary, with the MAP method giving more extensive qualitative information and the PAC method providing simplified quantification. The MAP method has been used extensively for NIOSH Health Hazard Evaluations and in a large epidemiological study of autobody shop workers conducted by Yale University. A patent has been issued for the PAC technology.

Impact:
The MAP method became the standard method for NIOSH field studies beginning in 1998. Numerous Health Hazard Evaluations in industries using many different types of isocyanates have been conducted since this time. A partnership was formed between Yale University, the University of Massachusetts Lowell, and NIOSH involving a large epidemiological study of worker exposure to isocyanates in autobody shops. The MAP method was chosen as the exposure assessment tool for this study. NIOSH initially performed the analyses of field samples, then transferred the technology to U. Mass., but continued to supply reagents and standards through the course of the study. A patent was ultimately obtained for the PAC technology. The lead researcher has been a member of an International Organization for Standardization (ISO) working group (ISO TC 146/SC2/WG4) developing international standards and other documents related to isocyanate sampling and analysis.

Use of a Hepatocyte Model for Identifying Biomarkers

Project Period:
1998 - 2001

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Co-Investigator(s):
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NIOSH

Abstract:
Knowledge of the nature of excreted urinary metabolites is key to the development of effective urinary biomonitoring methods. A lack of knowledge of the individual variability of chemical metabolism limits biomarker development. Since some individuals are more susceptible to adverse health effects, this study addressed this issue of inter-individual variability by developing an in vitro model system with which metabolism of xenobiotic chemicals could be studied. The ability to identify the most appropriate metabolites to use for biomonitoring will allow for more accurate exposure assessment and hence improved intervention measures. NIOSH, in partnership with the US EPA, completed a study to determine species-dependent and intra-human differences in biotransformation activities that may alter the bioavailability or toxicity of chemical exposures. To rapidly quantify CYP450 forms in human and animal hepatic microsomes, we developed an ELISA and determined protein content and activities in over 200 samples from adult human organ donors.

Impact:
NIOSH, in partnership with the US EPA, completed a study to determine species-dependent and intra-human differences in biotransformation activities that may alter the bioavailability or toxicity of workplace and environmental chemical exposures. To rapidly quantify CYP450 forms in human and animal hepatic microsomes, we developed an ELISA and determined protein content and activities in over 200 samples of microsomes from adult human organ donors. This work has resulted in the publication of four journal articles that have been cited over 40 times. In addition, EPA has used the data from this work to re-evaluate uncertainty factors used in risk assessments and has applied them to new risk assessments for trichloroethylene (revised RFC and RFD) and chloroform (RFC). In addition, this work has been used by ACGIH to develop a physiologically based pharmacokinetic model for acrylonitrile disposition in humans.

Biomonitoring Methods for Agricultural Exposures

Project Period:
1997 - 2004

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Abstract:
The heavy use of insecticides and herbicides with known acute and chronic toxicities presents a significant exposure risk for agricultural workers. In efforts to minimize this risk, urinary biological monitoring is an essential tool for assessing exposure to these pesticides since much of the exposure is through the skin. The development of improved and novel immunochemical techniques is paramount to the mission of protecting those who routinely work with agricultural and industrial chemicals. Moreover, the development of working multiplexed analyses has led to near real-time analyses of samples from field studies. Shortening the analysis time allows for meaningful interventions that will reduce exposures and the risk of future disease related to these exposures.

Impact:
The development of expedient and cost-effective, high-throughput methods is having great impact on the direction of occupational exposure research throughout the Institute. Because of decreases in cost per assay, low sample volume requirements and faster turnaround, field studies can be designed to better assess chemical exposures. For example, to conduct conventional analysis of trichloropyridinol (a pesticide metabolite) in urine requires extensive sample preparation and expensive analytical equipment ($10,000/100 samples/10 days). In contrast, using the method developed requires simple dilution of the sample and an inexpensive reader ($500/100 samples/8 hours). The ability to rapidly provide exposure data to project officers and study participants has increased urgency and impact since timely intervention will reduce these high and possibly dangerous exposures. This will result in the immediate occupational behavior modification and reduction of exposure for these workers.

Biomonitoring of Workers Exposed to Roofing Asphalt Fume

Project Period:
1998 - 2000

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Abstract:
DNA strand breaks and the ratio of 8-hydroxydeoxyguanosine (8-OHdG) to 2-deoxyguanosine were measured in peripheral blood leukocytes of roofers exposed to asphalt fume. The study population consisted of 26 roofers and 15 construction workers not exposed to asphalt during the past 5 years. Personal air monitoring was performed to measure exposure to total particulate and benzene-soluble-fraction of total particulate. Urinary 1-OH-pyrene levels were used as an internal biomarker of polycyclic aromatic compounds (PAC) exposure. Total particulate, benzene solubles and PACs were significantly higher for coal-tar exposed workers than for roofers not exposed to coal tar. Urinary 1-OH-pyrene levels were higher in coal-tar-exposed roofers. PAC exposure was highly correlated with urinary 1-OH-pyrene. When stratified by 1-OH-pyrene excretion, DNA strand breaks increased and leukocyte 8-OHdG/dG decreased in a dose-dependent manner. Significant changes in DNA damage appeared to be linked to PAC exposure.

Impact:
Several studies attempting to assess the human genotoxicity of asphalt fume have not accounted for potential confounders other than smoking. The present study demonstrates that substantial PAC exposure can occur as the result of old-roof tear off. While present results indicate the role of asphalt fume to be minimal, it is clear that the work practices surrounding tear-off of roofs containing coal tar may be an unrecognized health hazard. NIOSH considers coal tar products to be potential carcinogens and recommends an exposure limit (REL, 10-hr TWA) of 0.1 mg/m3. OSHA's permissible exposure limit (PEL, 8-hr TWA) is 0.2 mg/m3. In the present study, 0.35 mg/m3 TWA serves as an approximate average exposure to coal-tar. This value exceeds the OSHA PEL for coal-tar exposure from fume. A possible consequence of exceeding this limit is increased DNA damage.

Analytical Techniques for Silica

Project Period:
1998 - 2000

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Abstract:
Respirable crystalline silica has long been known as a harmful agent that affects pulmonary health of exposed workers. This research pursued advancements in infrared (IR) laboratory methods to measure silica content of mine dusts. At the time of this program, the method to quantify silica in coal mine dusts was labor intensive and time consuming. A quicker and easier method would have permitted more rapid responses to overexposure and facilitated wider scale monitoring. By automating analysis aspects, human error would be reduced, provide a more uniform technique for analysis would be provided, and therefore accuracy would be improved. This research produced specialized software for the analysis of infrared spectra, a tool that not only helps with crystalline silica analysis, but also aids in the analysis of any contaminant or material of interest. The software developed is a patent-pending invention that will advance the scientific community's capabilities for more refined IR analyses and research involving IR analytical techniques.

Impact:
The creation of the IR analysis software provides a useful tool for the field of occupational health in several respects. It allows more detailed research into the area of crystalline silica analysis, the mining-related field of its original intent. Methods for crystalline silica may be refined and made more accurate by an easier processing of spectral data. Inter-laboratory variation in analysis is reduced by providing uniform methodology in data processing, improving measurement agreement. Similarly, the versatile capabilities of the software assist IR method development and refinement for many contaminants of interest, regardless of the industry involved. IR analysis is a common and fundamental tool of analysts; any progress with the technique impacts many fields and applications. Securing and licensing patents for the invention will have a general impact on spectrometric practices. The invention advances the technical field of spectrometry, for whatever application quantification is performed.

Imaging Early Response to Occupational Exposures or Injury

Project Period:
1998 - 2001

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Patricia Schleiff, MS
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David Murray, PhD
NIOSH

Abstract:
This project devised and demonstrated a method for non-invasive detection of lung fibrosis, e.g., silicosis, as an early active disease process. A novel tracer was used in a positron emission tomography ("PET-Scan) rabbit animal model test to detect and localize active synthesis of collagen scar tissue in the first 5 months of disease development with 90% or greater sensitivity or specificity. This was to provide early detection of lung fibrosis to improve disease surveillance and to permit determination of the active status of disease under medical management. A magnetic resonance imaging system (MRI) was set up in NIOSH to provide advanced non-invasive imaging of animal model studies of occupational disease or injury. This work continued from 2002 until mid-2003 under the title "Imaging and grading occupational disease or injury." Additional information on results is found there.

Impact:
The fluoro-proline tracer PET-scan method test was completed in the subsequent project. "Imaging and grading occupational disease or injury", and published. Possible uses of a fully tested method for surveillance of public or workforce exposed to respirable materials of uncertain risk, e.g., first responders to calamitous events, were brought to the attention of the "Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers" assembled following the World Trade Centers disaster.

Surface Chemistry Characterization of Respirable Particles

Project Period:
1997 - 2001

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William Chisholm, Ph. D.
NIOSH

Abstract:
This project and two integrated projects (Characterization of Inorganic Dust Exposures and Toxic Respirable Particle Biological Surface Interactions) sought surface properties and interactions controlling respirable particle expression of toxicity. This project researched the chemical bases for respirable silica toxicity by examining particle surface functional groups and their interactions with biomolecular species possibly controlling for silica toxicity, as conventional measures of silica dust exposure do not always correlate with disease risk. Spectroscopic methods were used which probe the chemical interactions at particle surfaces. Principal studies involved the chemistry and molecular interactions of lung surfactant with respirable silica and kaolin dusts. This project was continued as particle Surface Program: Chemistry Characterization in United States Government fiscal year 2002.

Impact:
Silica particle surface chemistry effects of dust on in vitro toxicity and particle surface composition property comparisons with silicosis or pneumoconiosis disease risk were presented by invitation at the NIOSH-OSHA-MSHA Tri-agency

Workshop on Silica Measurement and Control,"Silica particle surface properties and disease risk," Morgantown, WV. 2000. Information on surface chemistry of surfactant adsorption and effects on silica in vitro toxicity were presented by invitation at the 6th European Environmental Hygiene Meeting: "Phospholipid adsorption by quartz and in vitro cytotoxicity and DNA damage", 1997. Subsequent research was pursued as the project entitled, Particle Surface Program: Chemistry Characterization.

Monitoring System for Human Responses to Workplace Conditions

Project Period:
1995 - 2000

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
John R. Powers
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Dr. Hongwei Hsiao
NIOSH

Abstract:
This project developed a human activity video-synchronized, integrated multi-channel monitoring system to monitor worker stress exposures. The system is capable of acquiring video-frame-synchronized, 30-channel telemetry EMG, O2 consumption and CO2 generation data with a bandwidth of 3,000 Hz per channel for a duration of 30 minutes. The system is useful for identifying workers' critical task elements that contribute to overall stress exposure, allowing engineering control strategies to be implemented to control the stress exposure. A software interface between this system and the University of Wisconsin-Madison Multimedia Video Task Analysis (MVTA) software was developed. With this interface, researchers are able to use the advanced MVTA motion analysis software to analyze the worker stress exposure data acquired by the NIOSH monitoring system.

Impact:
This project developed a tool for in-house use and a patentable methodology for the development of future, commercially-manufactured systems for use in a multitude of research applications.

• Fertility & Pregnancy Abnormalities •

Health Effects Associated with Occupational Cycling

Project Period:
2003 - 2006

Researcher Name:
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NIOSH

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Key Partner(s):
Maureen Becker
International Police Mountain Bike Association

Dr. Marsha Guess
Albert Einstein School of Medicine

Dr. Kathleen Connell
Yale University College of Medicine

Co-Investigator(s):
Brian Lowe, PhD
NIOSH

Mike Breitenstein
NIOSH

John Clark
NIOSH

Abstract:
Studies to evaluate tissue pressure on the load bearing regions of the urogenital triangle, feet, and hands as a function of seat design and bicycle fit have been initiated in response to health concerns of bicycling police officers (both male and female). Saddles without a protruding nose were studied, and it was determined that these saddles eliminate perineal pressure without a significant increase in hand and foot pressure. No nose saddles are being evaluated as an intervention to alleviate perineal parathesia sexual dysfunction. Reproductive health assessments are being evaluated before the no nose saddle intervention and after six months of use.

Impact:
The results from the "Effect of Saddle Design on the Perineal Pressure of the Bicyclist" manuscript were published in several newspapers. The trade journal Business Insurance also reported these results. Men's Health magazine will have a story on sexual function and bicycling and will highlight this research.

Neuro-immune-endocrine Modulation by Octamethylcyclotetrasiloxane

Project Period:
1999 - 2003

Researcher Name:
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Dori Germolec
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Michael R. Miller
West Virginia University
Co-Investigator(s):
Bin He
NIOSH

Abstract:
Octamethylcyclotetrasiloxane (D4) is a low molecular weight cyclic silicone used in the synthesis of larger silicone polymers and in the formulation of a variety of personal care products. Serum estradiol levels decreased in a dose-dependent manner after exposure to 100 mg/kg to 1000 mg/kg of D4 in B6C3F1 female mice. Studies with adrenalectomized animals demonstrated that the decreased serum estradiol levels were not due to elevated serum corticosterone levels. Uterine wet weights in ovariectomized mice were significantly increased in a dose-dependent manner by exposure to 250 – 1,000 mg D4/kg, but four other siloxanes were inactive. The estrogen receptor antagonist ICI 182,780 completely blocked the D4-induced increase in uterine weight, and ovariectomized estrogen receptor knockout mice showed no increases in uterine weights when orally exposed to D4 or estradiol. D4 showed significant competition with 3H-estradiol for binding to estrogen receptor-α, but not estrogen receptor-β. The data presented here indicate that D4 has estrogenic activity, and that these effects are mediated through estrogen receptor-α.

Impact:
The data and publication of this data along with data published by the manufacturer resulted in this product being removed from personal care products.

In vitro Assessment of Reproductive Toxicity

Project Period:
1996 - 1999

Researcher Name:
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Co-Investigator(s):
Linda Huffman, Ph.D.
NIOSH
Mike Miller, Ph.D.
West Virginia University

Abstract:
Concern exists that exposure to chemicals called endocrine disrupters (ED) is associated with the recent increased incidence of male reproductive disorders. The objectives of this project were to determine whether chemicals used as surfactant additives in many manufacturing industries or agricultural pesticides adversely affect male reproductive functions using rat cultured Leydig cells (LC) as a model. Primary cultures of rat fetal LC were established to evaluate the effects of ED on LC testosterone (T) production. T is a male hormone essential for many reproductive functions. In cultured fetal LC, octylphenol (OP), a surfactant additive, had a biphasic effect on hCG-stimulated T formation. Low concentrations of OP (1-10 nM) increased T, while higher concentrations (500-1000 nM) decreased T formations. These results emphasize the importance of dose in influencing the direction of response to a chemical.

Impact:
In 1995 and 1996, Congress passed the Safe Drinking Water and Food Quality Protection Acts directing the EPA to develop tests to screen potential ED chemicals in drinking water and foods, because of the concern that these chemicals in the environment and workplace are having adverse effects on human health. The current assumptions are that these chemicals act as estrogen agonists or antagonists, or as androgen antagonists through the ER or androgen receptor (AR), respectively. The results of this project demonstrate that the response to a chemical may be different, depending on the range of doses applied and that the mechanism of action may not be through the ER. Because the current emphasis, to identify ED chemicals, is based on their ability to bind to the ER or AR and/or to activate or inhibit ER- or AR- activated genes, using these test criteria may miss potential chemicals that exert their effects through alternative pathways.

Testicular Toxicity of Occupational Chemicals

Project Period:
1999 - 2003

Researcher Name:
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NIOSH

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Key Partner(s):
n/a

Co-Investigator(s):
Linda Huffman, Ph.D.
NIOSH

Mike Miller, Ph.D.
West Virginia University

Abstract:
It has been proposed that exposure to endocrine-disrupting (ED) chemicals has adversely affected the reproductive health of males. The objectives of this project were to determine whether chemicals used as surfactant additives in many manufacturing industries or agricultural pesticides adversely affect male reproductive functions, using rat cultured Leydig cells (LC) as a model. These studies evaluated whether different ED chemicals exerted their effects on LC testosterone (T) formation by a common mechanism, and whether an age-dependent difference in the sensitivity of LC to ED chemicals existed. Because T plays a critical role in regulating reproductive functions during fetal, prepubertol and adult phases of maturation, changes in T formation could, in part, explain many of the adverse actions of ED chemicals on male reproduction.

Impact:
In 1995 and 1996 Congress passed the Safe Drinking Water and Food Quality Protection Acts directing the EPA to develop tests to screen potential ED chemicals in drinking water and foods, because of the concern that these chemicals in the environment and workplace are having adverse effects on human health. It is currently assumed that these chemicals act as extrogen agonists or antagonists through the ER or as androgen antagonists through the AR. Accordingly, tests being developed to identify potential ED chemicals is based on their ability to bind to the ER or AR, or to activate or inhibit ER- or AR- activated genes. The results of this project demonstrate that some ED chemicals may exert their effects through other mechanisms and that there may be age-related differences in the pattern of reponse to a chemical.

Reproductive Toxicity of Occupational Chemicals

Project Period:
2003 - 2006

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Co-Investigator(s):
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NIOSH

Abstract:
Concern has been raised that occupational or environmental exposure to chemicals, called endocrine disrupters (ED), has adversely affected the reproductive health of humans. To what extent occupational exposure to these chemicals contributes to these conditions and how they elicit their effect are not known. This project will evaluate the effects of methoxychlor (M), a pesticide DDT and the reported "active" metabolite (HPTE) of M, on testosterone (T) formation by cultured Leydig cells (LC) isolated during different stages of maturation. In addition, this project will evaluate whether M or similar-acting chemicals alter steroidogenesis in ovarian follicles. If specific steps are affected by M in both LC or follicles, the specific mechanism(s) by which M alters steroidogenesis will be determined.

Impact:
In 1995 and 1996 Congress passed the Safe Drinking Water and Food Quality Protection Acts directing the EPA to develop tests to screen potential ED chemicals in drinking water and foods, because of the concern that these chemicals in the environment and workplace are having adverse effects on human health. It is currently thought that these chemicals act as estrogen agonists or antagonists, or as androgen antagonists through the ER or AR, respectively. The results of this project, to date, have indicated that the prototypical ED, M, and its reported active metabolite, HPTE, which have been reported to act as a xenoestrogen or an androgen antagonist through the ER and AR, respectively, do not utilize these pathways in LC. Because the current tests to identify ED chemicals is based on their ability to bind to the ER or AR and/or to activate or inhibit ER- or AR- activated genes, these tests may miss potential chemicals that exert their effects through alternative pathways.

Endocrine Disruption: Consequences for Occupational Exposures

Project Period:
1996 - 2000

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Michael Miller, Ph.D.
West Virginia University

Co-Investigator(s):
n/a

Abstract:
Research was conducted to determine the potential health-effect consequences of endocrine disruption relative to workplace exposures. One area of research studied the impact of estrogenic substances on the stimulation of breast cancer cell proliferation. Another focal area determined whether alterations in thyroid hormone status were associated with more severe reactions to inhalation hazards, which have been linked to pulmonary disease. Research was also directed towards investigating functional responses of lung cells, since it is known that these cells participate in pulmonary responses to inhaled hazards and can be modulated by hormonal factors.

Impact:
This research advances our knowledge and understanding of mechanisms and disease processes resulting from endocrine disruption. Although endocrine disruption is a topic of great concern, a basic understanding of the mechanisms and effects involved is limited. The results from the present research help fill this gap. This has the potential to significantly impact the identification of conditions or situations which may pose a substantial risk for worker health.

Reproductive State, Xenoestrogens, and Work

Project Period:
2001 - 2004

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NIOSH

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n/a

Co-Investigator(s):
n/a

Abstract:
Research was conducted to determine the potential health-effect consequences of altered endocrine states relative to workplace exposures. One area of research investigated how female reproductive status may alter responses to potential inhalation hazards. Another research focus determined the extent to which thyroid dysfunction can affect lung responses to workplace hazards. Research was also directed towards investigating functional responses of lung cells since it is known that these cells participate in pulmonary responses to inhaled hazards and can be modulated by hormonal factors.

Impact:
This research advances our knowledge and understanding of basic mechanisms and disease processes resulting from altered endocrine states. The consequences of altered endocrine states relative to the health-effect impact of workplace exposures are relatively understudied. The results from the present research help fill this gap. This has the potential to have a significant impact on the identification of conditions or situations which may pose a substantial risk for worker health.

Female Reproductive Effects of Exposure to Jet Fuel at USAF Bases

Project Period:
1996 - 2000

Researcher Name:
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Key Partner(s):
University of Cincinnati, OH
United States Department of Defense
United States Army
United States Air Force

Co-Investigator(s):
Edwin Knecht
NIOSH

Abstract:
Female Air Force personnel are exposed to large volumes of jet fuel. More than 95% of these women are in the prime of their reproductive years. Exposure to components of jet fuel fumes is associated with menstrual disorders, infertility, spontaneous abortions, and adverse fetal effects. A collaborative study was conducted with University of Cincinnati, U.S. Department of Defense, U.S. Army, and U.S. Air Force (USAF) to assess the effects of jet fuel exposure on female reproductive health of USAF personnel. Women with elevated levels of hydrocarbons in their breath experienced reduced

levels of the hormonal trigger for ovulation. Racial differences were also detected in some of the endocrine endpoints. Results from this study helped the Department of Defense and its female personnel reduce workplace exposure to jet fuel, and prompted an ongoing follow-up intervention assessment study, to reduce the social, economic, and personal cost caused by reproductive disorders.

Impact:
Results of the assessment studies were used by the DOD/ Army and other entities to identify ways to reduce jet fuel exposure, where indicated, thereby establishing safer working conditions. The impact was to try to reduce female reproductive dysfunction, sex hormone-related disease, and emotional burdens, while increasing job performance. The adverse relationship between hydrocarbon breath levels and reduced periovulatory LH levels could compromise ovulation and luteal function in exposed women. The United States Air Force and NIOSH are collaborating to assess the effectiveness of intervention measures to reduce exposure of USAF personnel exposed to jet fuel.

Methods to Evaluate Reproductive Potential of Women

Project Period:
1999 - 2006

Researcher Name:
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Key Partner(s):
NIEHS
McMaster University, Ontario
University of California, Irvine
University of California, Los Angeles
Emory University

Co-Investigator(s):
John Clark
NIOSH
Juliana Meadows, PhD
NIOSH

Abstract:
This project addresses the risk of workplace exposures on the reproductive potential of women by developing and applying methods to biologically monitor the reproductive health of populations of women exposed to chemicals, radiation, physical exertion, stress, and other forms of occupational hazards. The project also provides intervention measures and council in situations where female reproductive hazards are identified. The project has generated state-of-the-art methods for assessing women's reproductive hormones in population studies in a convenient manner. The methods have had a substantial impact on this field of research, have yielded a wealth of information, have sparked statistical methods, and have revealed toxic conditions in populations. Results from this research will continue to help identify workplace hazards, isolate the hazards, and reduce the social, economic, and personal cost imposed by reproductive disorders.

Impact:
The time-resolved fluoroimmunoassays developed in this project are central to NIOSH research on women's reproductive health: one has been shown to be superior to others in detecting the endocrine signal that triggers ovulation; two motivated the manufacture of commercial assays. The project has attracted several collaborative studies - national and international - on a range of occupational exposures. Results from the pilot study of the exposed Cree population provided justification for further study of this population. Project results were used to generate improved statistical approaches for assessing female reproductive parameters. One algorithm uses fuzzy set theory and optimized using signal detection theory to detect hormone peaks and normal menstrual cycles in sequences of measurements with arbitrary starting points and lengths. Another is a semi-parametric mixture model that uses multiple independent markers of ovulation to account for measurement error to correct bias in estimates of day-specific fecundability.

Acrylamide Workers' Reproductive and Neurological Health

Project Period:
2003 - 2007

Researcher Name:
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FDA
Gary Meyers, Hubert Vesper
NCEH

Co-Investigator(s):
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NIOSH
Steven Schrader, PhD
NIOSH
Leo Blade
NIOSH

Terry W. Turner
NIOSH
Edward Hitchcock, PhD
NIOSH

Abstract:
Acrylamide is an odorless, crystalline solid with extensive current use and growing commercial potential. In the United States, it is used to produce polyacrylamides for water treatment, and adhesive formulations used in sewer and soil grouts, paper production, and coatings. Acrylamide is toxic and potentially harmful by all routes of exposure. The principal occupational health concerns have focused on its neurotoxic and carcinogenic potentials. Epidemiological studies of acrylamide describe the neurotoxicity in workers, however workplace studies have not demonstrated carcinogenicity. Animal reproductive toxicity studies conducted by the NTP Program reveal acrylamide and its congeners (hydroxy, methyl, and methylene bis acrylamide) to be potent male reproductive toxicants, leading to concern about their effect on the reproductive health of male workers. Since many workers are exposed to acrylamides and the production rates are increasing, acrylamide exposure could substantially impact the health of workers in many differing job categories.

Impact:
This project is in its third year, therefore the impact cannot be assessed at this time. The potential impact of the project will result in the acceptance and use of hemoglobin adduct biomarkers by industry. Through formal announcement of the project in the Federal Register, some acrylamide producers have shown interest in partnering with NIOSH to evaluate exposure by both air monitoring and biomonitoring. Results of this study will contribute information on human exposure to acrylamide and potential reproductive and neurological effects that is available for risk assessment and regulatory decision-making.

Investigations on the Effects of Pesticides as Endocrine Disruptors

Project Period:
1997 - 1998

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
Kenneth Cheever
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Stephen Skaggs
NIOSH
John Clark
NIOSH

Abstract:
This project had two purposes: to focus on development of an animal model for endocrine disruption of male reproduction and to demonstrate the potential effects on secondary sex development. Juvenile rabbits were exposed by dermal route to an antiandrogenic fungicide, vinclozolin (100 mg/kg), during secondary sex development (3rd & 4th months of life) and held to maturity (6 months of age) for evaluation of male attributes and semen quality. The rabbit was selected because of its utility for relatable semen analysis. This study demonstrated the following effects associated with vinclozolin exposure: a borderline significant ($p=0.059$) smaller body weight gain, a significant ($p=0.016$) lower weight of accessory sex glands, a significant ($p=0.017$) higher pooled sperm count, and significantly ($p>0.000$) larger sperm heads. No decreases in libido, sperm count, or testicular size were found, as expected.

Impact:
The results of our studies were published in Andrologia in 2000 and were recognized as the first male reproductive model to evaluate the effects for a known endocrine disrupting antiandrogen for the adolescent stage. The paper was nominated for the paper of the year award by the European Reproductive Society.

Workers Exposed to NTP Prioritized Reproductive Toxicants

Project Period:
1997 - 2001

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Robert Chapin
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Robert Kavlock
US EPA, NEEHRL
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George Daston
American Industrial Health Council

Co-Investigator(s):
Steven Schrader, PhD
NIOSH
Stephen Skaggs
NIOSH (No longer with NIOSH)
John Clark
NIOSH

Abstract:
Population studies that evaluate human reproductive impairment are time-consuming, expensive, logistically difficult, and, with limited resources, must be prioritized to effectively prevent adverse health effects in humans. Interactions among health scientists, unions, and industry can serve to identify populations exposed to potential hazards and develop strategies to evaluate and apply appropriate controls. This project developed a systematic method for prioritizing chemicals that may need human reproductive health field studies. Rodent reproductive toxicants identified from the National Toxicology Program (NTP) Reproductive Assessment by Continuous Breeding (RACB) protocol were prioritized on the basis of potency of toxic effect and population at risk. This model for prioritization links NTP findings with data from the National Occupational Exposure Survey (NOES) and the Hazardous Substance Data Base (HSDB) or the High Production Volume Chemical Database (HPVC) to prioritize chemicals for their potential impact on worker populations.

Impact:
The prioritization matrix has served the research community well. NIOSH/NORA utilized this matrix in its grant request for proposals. Currently, boric acid is being studied by this granting process. The prioritization matrix has driven much of the NIOSH/DART Reproductive health research. Information on the use and potential of exposures to acrylamide, tricresyl phosphate, and N,N-dimethylformamide from various workplaces has been gathered. Pilot exposure assessment studies are currently being conducted.

Methods for Assessing Male Reproductive Toxicity

Project Period:
1996 - 2004

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Co-Investigator(s):
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NIOSH
Richard Salomon, DVM
NIOSH
John Clark
NIOSH
Mike Breitenstein
NIOSH
Hazel Patterson
NIOSH

Abstract:
Male reproductive hazards have been shown to attack at least one of four major sites (the endocrine system, the testes, the accessory sex glands, and sexual function). The goal of this project was to implement new technologies and clinical methods for assessing these sites to measure toxic effects found in occupational field studies. These field studies were conducted with partners to assess the reproductive health of men exposed to potential hazards. The National Institute for Child and Human Development (NIH) asked the NIOSH research team to assess the reproductive health of men in a large fertility and chemical exposure study. The NIOSH team developed a method for next day shipping of semen samples mainlining semen quality for fecundity testing.

Impact:
The establishment of a male reproductive health assessment profile has created an opportunity for NIOSH to become involved in occupational health studies of male workers around the world. It created a forum for disseminating research needs and results. The results of the utilization of this health profile have instigated several collaborative research projects with several universities and research agencies. Collaborators included the University of Cincinnati, University of Minnesota, McMaster University (Canada), University of Tromso (Norway), US Army, NIH, Health Canada, Russian Ministry of Health and the National Institute of Occupational Health, Norway.

Field Application of Male Reproductive Health Biomarkers

Project Period:
1996 - 2002

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Dr. Jon Odland
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Dr. Yngvar Thomassen
NIOH, Norway
Dr. Vincent Garry
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Co-Investigator(s):
Michael Breitenstein
NIOSH
John Clark
NIOSH
Hazel Patterson
NIOSH
Terry Turner
NIOSH

Abstract:
State of the art research methods in assessing male reproductive function are implemented in occupational field studies. These field studies are conducted with partners to assess the reproductive health of men exposed to potential hazards. A reproductive field investigation of pesticide applicators was conducted with the University of Minnesota. The reproductive health of men working nickel refineries was studied in collaboration with McMaster University, Ontario, Canada and the KOLA Laboratory of Occupational Health, Kirovsk Russia. The reproductive health of bicycling policemen was studied in Long Beach, CA as part of a Health Hazard Investigation.

Impact:
The bicycle saddle study provided the scientific evidence that prolonged bicycling may affect male reproductive health. The primary recommendations of the study were to ensure proper bicycle fit and to take breaks from riding if symptoms of genital numbness occurred. The results of this study were featured in several news forums including the Wall Street Journal, Time Magazine, the Times Herald-Record and CNN. The findings of this study led to a NIOSH intervention study of no-nose bicycle saddles. The results of the nickel refinery study in Russia were provided to the Nickel Producers Environmental Research Association (NiPERA). NiPERA held a workshop entitled "Metals and Reproductive Effects Workshop" in Copenhagen, Denmark, January 2005 to discuss these data to develop exposure limits for nickel. The observation of adverse reproductive health in the oxygen purification plant has led the KOLA Occupational Laboratory in Kirovsk, Russia to evaluate this work site.

• Hearing Loss •

Accommodation of Noise-Exposed, Hearing-Impaired Workers

Project Period:
2001-2006

Researcher Name:
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James Griffin
General Motors Corporation

Co-investigators:
Thais C. Morata, PhD
NIOSH
Babette L. Verbsky, PhD
NIOSH

Abstract:
Workers with hearing impairment face special problems, especially when working in hazardous noise environments which require them to wear hearing protectors. These problems can include a diminished ability to monitor the work environment (e.g., warning signals, equipment sounds, etc.), impaired communication ability, and increased risk of accidents. Standard hearing conservation practices do not take into account the special problems encountered by hearing-impaired workers, and hearing conservation professionals do not have the information necessary to make appropriate recommendations to accommodate these workers. This project proposes to develop a standard evaluation and intervention technique which will provide hearing conservationists and others with the necessary tools to manage hearing-impaired, noise-exposed workers so that they can continue to perform their jobs safely while preventing additional hearing loss.

Impact:
Currently, no regulatory or professional standards exist for accommodating the special needs of noise-exposed, hearing-impaired workers. Occupational noise regulations do not distinguish between workers with normal versus impaired hearing,

even though their needs may be very different. The Americans with Disabilities Act of 1990, which requires employers to make reasonable accommodation for handicapped workers, provides specific guidance on communication issues for the completely deaf, but does not address management issues for other hearing-impaired workers. This project will therefore provide the first comprehensive strategy for evaluating and accommodating noise-exposed, hearing-impaired workers so that they can perform their jobs safely without risk of further hearing impairment.

Noise Control: Web-based Outreach to Construction and Mining

Project Period:
2002-2005

Researcher Name:
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NIOSH

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Key Partner(s):
n/a

Co-Investigator(s):
n/a

Abstract:
Through this project, NIOSH developed and is maintaining information systems dedicated to translating research findings from the NORA noise program of research into usable recommendations, emphasizing the needs of construction and mining industries. This involves working with noise team scientists to synthesize their peer-reviewed publications and research results into both technical and lay documents packaged for Web distribution. Novel web products have been produced to best communicate research results and recommendations. Examples of new products include an interactive online noise meter, a searchable hearing protector compendium, and a searchable database for various noise levels of power hand tools. Usability studies are being conducted to assess various Web formats and the usefulness of the site to a number of targeted audiences such as hearing health professionals, safety and health professionals, and the public.

Impact:
The direct impact of the redesign of noise topic pages has been improved outreach to various NIOSH publics concerned with hazardous noise and the prevention of occupational hearing loss. Improved outreach has been documented through the increasing number of Web page hits and number of links to the NIOSH noise pages, the results of a pilot usability study, and unsolicited feedback received by the webmaster. A corollary benefit has been improved communication and cooperation among NIOSH noise and hearing loss researchers, especially with regard to highlighted products such as the hearing protector compendium and the database of noise levels for power hand tools.

Hearing Loss Intervention for Carpenters

Project Period:
2000-2005

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NIOSH

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Key Partner(s):
United Brotherhood of Carpenters and Joiners
Art Galea
Joint Apprentice Training Center
Bill Smith
Joint Apprentice Training Center

Co-Investigator(s):
n/a

Abstract:
This study is one part of an integrated, large, multi-divisional effort that was designed to address the pervasive noise-induced hearing loss problems within the construction industry. The purpose of this portion of the study was to provide evidence regarding behavioral changes demonstrated by apprentice carpenters after participating in a comprehensive hearing loss prevention program. As part of their program, apprentices were trained with new communication/training materials capable of shaping positive behaviors regarding hearing protector use. This involved developing training materials that address or remove the barriers that prevented carpenters from taking responsibility for protecting their hearing. Worksite observations were conducted at baseline, within a few weeks after training, and at one year follow-up. NIOSH worked closely with several external partners to implement and evaluate this approach as well as the validation measures used to assess behavior on the worksite.

Impact:
The direct impact of the behavioral observations conducted for this study was to confirm that the NIOSH approach designed for the construction industry can result in measurable behavior change on worksites. Based in part on the overall study with carpenter apprentices, OSHA convened stakeholder meetings to explore the development of hearing conservation programs for the construction industry. The United Brotherhood of Carpenters and Joiners plans to institutionalize the training at their 150 apprentice training centers. The US Navy has expressed interest in field testing the NIOSH approach, training program, and assessment tools, including behavioral observation, at shipyards. Because construction

tools and tasks are similar to shipbuilding tools and tasks, this effort would validate the methods and materials in another sector whose workers are suffering significant occupational hearing loss.

Health Communication Interventions for Hearing Loss Prevention

Project Period:
1999-2005

Researcher Name:
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NIOSH

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Key Partner(s):
White County Coal
International Union of Operating Engineers
Big Ridge Inc.
Consol Energy

Co-Investigator(s):
Roberta Hudak
NIOSH
Richard Unger
NIOSH
Dana Reinke
NIOSH
David Byrne
NIOSH

Abstract:
This project tested the effectiveness of a variety of health communication interventions on actions taken to prevent hearing loss, with an emphasis on the most frequent causes of inadequate prevention. Stakeholder input was used to identify potential interventions which were developed and field tested with a worker population. Intervention effectiveness was evaluated using a combination of knowledge, skill, and behavior change assessment measures.

Impact:
The simulator was released on CD-ROM and now has hundreds of users and supporting organizations that include the Mine Safety and Health Administration (MSHA), the Council for Accreditation in Occupational Hearing Conservation (CAOHC), and the National Hearing Conservation Association (NHCA). The Roll-Pull-Hold this technique is being disseminated through an instructional page and 1-minute video clip on the NIOSH website. We expect the short-term benefits of these communications interventions to result in long-term exposure and hearing loss reductions, and plan to conduct a long-term evaluation in a follow-on project.

Audiometric Assessment in NHANES IV

Project Period:
1997-2004

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Abstract:
This project developed baseline data on hearing and balance in adults through support of audiometric and balance testing in the National Health and Nutrition Examination Survey (NHANES). NHANES collects nationally-representative data on the health and nutritional status of U.S. residents through interviews and physical examinations. Support activities included protocol development, technician training, oversight of data collection, equipment maintenance, assistance with statistical analysis, and dissemination of results. Hearing data were collected on more than 6,000 survey participants aged 20-69. The audiometric protocol included otoscopy, immittance, pure-tone air conduction thresholds, and relevant questionnaire items. Balance examinations were conducted on participants aged 40 and older. The balance protocol consisted of a modified Romberg exam in which visual, proprioceptive, and vestibular inputs to the balance system were evaluated alone and in various combinations. These data provide a contemporary reference population for studies of hearing loss and balance disorders among occupationally-exposed sub-populations in the U.S.

Impact:
NHANES provides the first baseline measure of hearing loss in US adults in thirty years, which is essential for planning and charting progress in hearing loss prevention. It provides a contemporary reference population to which hearing levels in sub-populations can be compared. It allows the estimation of hearing loss prevalence, enabling prevention programs to be targeted appropriately. The NHANES audiometric data are the source of baseline measures for at least five hearing-related objectives in Healthy People 2010. And the NHANES

audiometric protocol has been implemented in several other large-scale epidemiologic projects, both in the US and abroad. In time, this will produce a large body of comparable audiometric data for monitoring hearing health across the world.

Definition and Assessment of Engineering Noise Controls

Project Period:
2001-2005

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Co-Investigator(s):
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Abstract:
This project developed an informational database for commonly used power tools in occupational settings. The database is particularly helpful in determining the "real-world" noise level of power tools as they are used on the job. The database contains such information as sound power levels, sound pressure level and downloadable sound exposure files. This project also sponsored student engineering teams and tasked them to identify noise emission sources on various power tools and to make recommendations to reduce those emissions. NIOSH provided the students new table saws, nail guns, circular saws, pneumatic impact wrenches, jigsaws, and grinders and asked them to identify noise sources and develop new noise controls or apply existing controls to reduce overall noise emissions. These efforts support the reduction of noise induced hearing loss among construction workers by providing "buy quiet" and "designed quiet" information to power tool buyers and end users.

Impact:
The searchable database is the largest of its kind in the world and can be used by tool buyers and end users of powered tools looking for the quietest tools of a particular type. The noise control projects accomplished at the universities have shown that significant noise reductions can be made to the tools with simple and economical modifications of the existing design. The student presentations both on the internet and as presented at professional conferences provide a significant segue to the publication of the powered hand tools database and the awareness level required to motivate use of the database. These efforts support the reduction of noise-induced hearing loss among construction workers by providing "buy quiet" and "designed quiet" information to power tool buyers and end users.

Cross-Sectional Survey: Noise Exposure Patterns/Sources

Project Period:
1999-2007

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Peabody Energy

National Stone Sand and Gravel Assoc.

Consol Energy

BHP

Co-Investigator(s):
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Abstract:
This comprehensive study addresses worker noise exposure, equipment/activity-related noise data, and noise exposure/source information. The resultant database will be an up-to-date comprehensive profile of the noise exposures to the mining population as a function of equipment and activity-specific measures. This study is a crucial component in NIOSH's effort to develop engineering noise controls because it will define the sources of miners' dosages and the characteristics of those sources. Once this information is available, efforts can focus on the development and application of appropriate engineering control measures. Another project emphasis is the selection, use and evaluation of administrative controls to reduce worker noise exposures. Surface and underground coal, metal/nonmetal mines, and stone mines will be included in the study, although current efforts will emphasize underground and surface coal, coal preparation plants, surface and underground stone mines, and sand and gravel operations.

Impact:
The impact of this research can be measured by the increase in knowledge concerning which workers in the mining industry are overexposed to noise, the source of the overexposures, and where engineering and/or administrative noise controls are needed and would be most efficiently implemented. It is believed that this increase in awareness, especially at the mine sites surveyed, is resulting in less noise exposure and subsequently, less noise-induced hearing loss among mine workers. To date, surveys have been completed at 35 mines, where several thousand employees have been exposed to the results of this research effort.

Noise Sampling Strategies and Exposure Response Models

Project Period:
2001-2004

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Co-Investigator(s):
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Abstract:
There is evidence that impulsive noise may have a greater effect on hearing loss than continuous noise exposure at the same 8-hr time weighted average (TWA). This project improved on existing noise and hearing loss exposure-response analyses by determining the most accurate way of estimating the time-weighted average (TWA) and incorporating the combined effect of impulsive and continuous noise. Two main approaches to estimating the TWA noise exposure were compared: task-based assessment (noise levels associated with each task in a given job, combined with time-at-task) and dosimetry (full-shift personal monitoring). Additionally, repeated measures of noise over several points in time on individuals and jobs permitted an evaluation of how the precision of the exposure assessment approach affects the exposure-response analysis (manufacturing only). The study focused on fieldwork instrumentation/methods, field data collection, and data analysis of dosimetry and task-based observation.

Impact:
Based on the combination of results from this research effort and the cross-sectional survey project, the impact on the mining industry is primarily one of improved information/knowledge. Having conducted dosimetry and task observations at over 35 sites has allowed NIOSH researchers to describe the importance of conducting task observations along side standard dosimetry for effective noise exposure analyses. NIOSH researchers have been able to promote noise awareness, need for hearing protection, and exposure avoidance at mines where total employment is several thousand or more workers. This increased awareness can lead to a reduction of NIHL in the mining industry.

Comfort as a Predictor of Effective Hearing Protector Use

Project Period:
2003-2008

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Abstract:
The goal of the continuing project, Comfort as a Predictor of Effective Hearing Protector Use, is to conduct an assessment of the hypothesis that a worker's body size and shape are predictors of occupational hearing protector comfort. To prevent significant, permanent hearing loss, workers in noise must consistently and effectively use hearing protection. Hearing protectors which are not comfortable are not worn correctly and effectively by exposed workers. The anticipated outcome is the applicability of these predictors in determining successful choices for occupational hearing protection in noisy environments.

Impact:
Intended impacts are: to better understand and quantify the dimensions of HP wearability; to make hearing protectors more comfortable and less burdensome for the worker, and therefore remove a barrier to healthy behavior; to provide guidance for HP manufacturers to produce a more comfortable product; to bring researchers and manufacturers together to exchange

information and data in a meeting; and to have HP manufacturers incorporate the NIOSH findings into HP design.

• Indoor Environment •

A Health Hazard Study of Surface Drilling Operations

Project Period:
2000-2005

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Abstract:
NIOSH data indicates that by the age of 50, 90% of mine workers (also engaged in drilling activities) suffer noise induced hearing loss severe enough to be classified as a hearing disability. There are similar equipment and working conditions that exist at surface drilling sites (water well, construction) which suggest that operators at these locations may also be overexposed. One task for this project will be to develop engineering noise protection devices to protect drill operators from over exposure to noise on drill rigs. A second task for this project will be to correlate job activities to noise exposures and develop methods and recommendations to be administered during these drilling activities to reduce overall noise exposures to the respective workers.

Impact:
Based in part on the findings of this research, and the growing awareness of occupational hearing loss, drill rig manufacturers, owners and operators now have a knowledge base to apply alternatives to improve the noise protection of existing engineering controls, purchase or construct a proven partial cab design, issue new administrative controls, and enforce personal protective equipment to reduce over exposure to noise for drill rig operators. Numerous national and state drilling associations have solicited the results of this research via workshops, publications, and training materials.

Evaluation & Validation of a Novel Bioaerosol Personal Sampler

Project Period:
2004 - 2004

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Abstract:
The number of reported respiratory diseases associated with bioaerosol exposures is rapidly increasing and include such problems as irritation and immunologic and infectious diseases. Although the health consequences are evident, there has been difficulty in establishing an exposure-response relationship because of the poor correlation between measured fungal concentration and recorded health effect. While progress has been made to apply molecular techniques in microbial detection, there is a lack of sampling devices that provide adequate collection of airborne fungi compatible with the developed detection techniques. This project will develop a personal sampler that could collect breathing zone samples and is amenable with PCR and immunoassay-based sample analysis to enhance the assessment of workplace exposure to fungal aerosols.

Impact:
We have evaluated sampling techniques compatible with PCR and immunoassays and, as a result, developed a prototypical personal sampler for collecting airborne fungal spores. This novel sampler collects aerosols and deposits them directly into the analysis container (i.e., a microcentrifuge tube). This novel sampler has several advantages over conventional samplers: long-term samples are possible (the limitation of

impaction methods); there is no sample transfer loss since the transfer step has been eliminated (the limitation of filter cassettes); laboratory analyses are not dependent solely upon a single analysis method (the limitation of impaction methods) and there is no sampler adherence loss (the limitation of trying to wash microorganisms from filters). In addition, use of the novel sampler would be applicable in a variety of occupational settings from low bioaerosol concentrations (i.e., indoor environments) to high bioaerosol concentrations (i.e., agricultural setting) by varying sampling time periods and using sensitive analytical methods.

Investigation of IAQ Processes, Instrumentation, and Interventions

Project Period:
2001 - 2010

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Abstract:
Indoor environment has a significant impact on human health. The higher chemical concentrations and the tendency of people to spend most time indoors combine to increase human exposure to potentially harmful chemicals. The National Occupational Research Agenda Indoor Environment (IEQ) Team has identified the characterization and measurement of indoor pollutants as a priority research need. This study is determining IEQ instrumentation performance and the efficacy of engineering controls. The results of this study will yield data that will improve understanding of the impact of indoor environments on human health, the performance of various instruments used to assess IEQ, develop alternate means of determining IEQ, and develop and evaluate interventions to improve the quality of indoor air of commercial buildings.

Impact:
The research results will increase knowledge of indoor environment chemistry and measurement and will contribute to a recognized priority research need by the National Occupational Research Agenda (NORA) Indoor Environment Team: indoor pollutant characterization and measurement. The research results from this study will be disseminated for use in other workplaces through the publication of manuscripts in peer-reviewed and trade journals and presentations. They will be used by industrial hygienists and others responsible for measuring the levels of indoor contaminants. The results, if appropriate, will be used to revise and modify NIOSH recommendations. A number of the recommendations made during two field IEQ investigations have been implemented which should improve the air quality. Since various administrative and environmental interventions which were recommended under this project have been implemented at the homeless shelter in August 2003, there have been no further outbreaks of TB at this shelter.

Gas Phase Chemistry of Indoor Environments

Project Period:
2001 - 2004

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Abstract:
The investigation of the gas-phase reactions of volatile organic compounds found in indoor environments will be used to more clearly define indoor exposure, and provide insight into important chemical and surface structure(s) that influence indoor air quality and highlight potential analytical/sampling needs. The research direction will be influenced by data generated from Health Hazard Evaluations (HHEs) and by other identified gaps in indoor environment research. The research results will also address indoor pollutant characterization and measurement. The research results will technically transition to more accurate exposure assessment, better analytical tools for HHE sampling, and improved engineering control methods to reduce chemical contaminants.

Impact:
This research advances the fundamental knowledge of the gas-phase chemistry of indoor environments by identifying reactions, molecular structures and reaction mechanisms that can lead to the formation of potential irritants. This knowledge is necessary to remove or reformulate products used in the indoor environment to decrease worker exposure to irritants.

• Infectious Diseases •

Characterization of TB Aerosols and Implications on Control

Project Period:
2000 - 2004

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Abstract:
The spread of infectious agents is a major concern of the Centers for Disease Control and Prevention (CDC). A significant increase in tuberculosis (TB) infection from 1985-1993 has led to efforts to control the spread of TB in health care and other settings. Gaps in TB control research areas (especially specific engineering and respiratory protection interventions) have been delineated in the National Institute for Occupational Safety and Health (NIOSH) TB strategic planning process, NIOSH Proceeding of the Workshop on Engineering Controls for Preventing Airborne Infections in Workers in Health Care and Related Facilities, and the CDC National Action Plan to Combat Multidrug-Resistant Tuberculosis. The project addressed: the filtration efficiencies of N95 particulate respirators and surgical masks in controlling exposures, the decontamination of particulate respirators without adversely affecting filter efficiency, and to use of N95 filter media or other materials as barriers for aerosol particle collection under low flow enclosure conditions.

Impact:
The results of this project can serve as a basis for health care workers, health professionals, facilities engineers, the Occupational Safety and Health Administration, the World Health Organization, correctional facility workers, and others to identify, modify, and implement appropriate prevention control measures. Current guidelines recommend placing surgical masks on patients to drop the spread of infectious aerosols into the general environment where other preventive measures are impractical such as in ambulances. The results of the barrier material tests may be used to develop new alternatives to using surgical masks on potentially infectious individuals. The disinfection results could lead to the reuse of respirator filters safely which could reduce the costs associated with respiratory protection programs. This research could lead to a decrease in occupationally-acquired infectious diseases including TB in high-risk settings.

Genetic Variation in AZT Metabolism 7007

Project Period:
1999 - 2003

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Abstract:
In the event of occupational exposure to a source of bloodborne pathogens, care-givers, medical technicians, public safety workers and others receive chemoprophylaxis for HIV infection in the form of AZT or other antiviral agents. Blood cell DNA AZT levels, chromosomal aberration, HPRT and GPA mutations, AZT glucuronidation and phosphorylation in persons treated with AZT vary widely. Genetic polymorphisms in thymidine kinase, thymidylate kinase, pyrimidine nucleoside diphosphate kinase and UDP-glucuronosyltransferase are likely responsible for these variations. We will seek correlations between these genotypes and toxic and mutagenic end-points in 300 AZT treated persons. So far we have discovered 24 polymorphisms in TK1 and have characterized 6 of them. We have demonstrated wide inter-individual variation in incorporation of AZT into DNA of mammary epithelial cells in vitro that is dependent on TK1 activity.

Impact:
Pharmacogenomics is the science of inter-individual variation in drug metabolism and associated adverse health effects

of drug disposition. The knowledge gained from this project could help clinicians to make more informed risk/benefit decisions about AZT use in prophylaxis and tailor treatment to individuals following accidental occupational exposures. It is important that administration of medications is beneficial rather than detrimental; AZT is a drug that in some people could present more risk than benefit.

• Intervention Effectiveness Research •

Evaluation of State-Based Workplace Violence Prevention

Project Period:
2001 - 2004

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Abstract:
As the risks for workplace violence have been more completely described and recognized over the last decade, states and other policy-makers have begun to develop statutes, administrative regulations, or technical assistance information for workplace violence prevention. Unfortunately, there have been no rigorous evaluations of the effectiveness of any of the regulatory or other state-based efforts undertaken to date. The National Institute for Occupational Safety and Health (NIOSH) has conducted an inventory of state-based approaches to workplace violence prevention to serve as a resource for labor, industry, academic and other researchers/practitioners as well as workers who may be interested in local resources that are available to them.

Impact:
The results of this effort will be used as a resource for labor, industry, academic and other researchers/practitioners as well as workers who may be interested in local resources that are available to them.

A Model Hearing Conservation Program for Coal Miners

Project Period:
1999 - 2004

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Abstract:
The purpose of this project was to develop and implement a Hearing Conservation Program (HCP) specifically for coal miners that can serve as a model for all other similar mining operations. This research was conducted at a working underground coal mine in collaboration with Penn State under a cooperative agreement. The resulting Model HCP incorporates the best practices of well-run programs in other industries, while identifying and overcoming any obstacles present in this particular industry. The effectiveness of the Model HCP was evaluated over a 5-year period.

Impact:
Implementation of the current MSHA noise rule along with the concepts outlined in the Model HCP should have a positive and measurable effect for significantly reducing the occurrence and the progression of NIHL among coal miners. Development of the Model HCP showed that implementation of a systematic plan of intervention can demonstrate the effectiveness of hearing conservation efforts for the prevention of occupational NIHL among coal miners. The MHCP represents the best practices in the field with modifications for the coal mining industry, some novel innovations, and meets or exceeds the requirements in the MSHA (1999) noise rule.

Evaluation of a Best Practices Back Injury Prevention Program

Project Period:
1998 - 2001

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Abstract:
An intervention trial and cost-benefit analysis of a "best practices" back injury prevention program was conducted from January 1995 through December 2000. The intervention, consisting of mechanical lifts, a zero lift policy, and training on lift usage, started in January 1998 and injury rates/severity and injury-related costs were compared for 36 months pre- and 36 months post-intervention in a study population of 1,728 nurses. Significant reductions occurred in resident handling injury rates (61%), workers' compensation costs, lost workday rates (66%), and restricted workday rates (38%) post-intervention for full and part-time nurses of all age groups, and all lengths of experience at all study sites. Adjusted rate ratios were 0.39 (95%CI 0.29-0.55) for workers' compensation claims, 0.54 (95%CI 0.40-0.73) for OSHA 200 logs, and 0.65 (95%CI 0.50-0.86) for first reports of injury. The $158,556 investment in lifting equipment was recovered in 3 years. Post-intervention assaults on caregivers during resident transfers decreased 72%.

Impact:
Research conducted by NIOSH, the Veterans Administration, and international collaborators is reducing musculoskeletal injury rates among nursing personnel. This NIOSH field study demonstrated that a "best practices" musculoskeletal injury prevention program can significantly reduce injury rates, workers' compensation costs, lost workday rates, and restricted workday rates. A user friendly document has been drafted for nursing home owners, administrators, and safety and health professionals to present a strong business case for investing in safe resident lifting programs. The document will be disseminated to 16,000 nursing homes during United States fiscal year 2005. Additionally, NIOSH was invited by the American Nurses Association and the Veterans Health Administration to write two chapters in a text book being developed by Springer publishers for use in training nursing students in the U.S. Widespread adoption of these new methods could help prevent back injuries among nursing personnel. Over the next 5-10 years, a paradigm shift is expected to change the way nursing students are taught to lift patients and the reduction in resident lifting injuries in the U.S. is expected to continue.

Nursing Home Back Intervention Study

Project Period:
1991 - 1997

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Abstract:
One of the major issues in nursing homes is the frequent lifting and repositioning of heavy residents that exceed the lifting capacity of most caregivers. This study performed a biomechanical and psychophysical assessment of twelve different methods for transferring nursing home residents from a bed to a chair (nine battery-powered lifts, a sliding board, a walking belt, and a baseline manual method). The study demonstrated that mechanical patient lifts significantly reduce the nursing assistants' back compressive forces and remove two thirds of the lifting activities per transfer. The results of this lab-based study were used to identify optimum transferring methods that were further evaluated in a follow-up NIOSH field study conducted in collaboration with BJC Health System.

Impact:
This lab-based study served as a precursor to a separate NIOSH field study. The lab study showed that the use of mechanical lifting equipment could significantly reduce exposures to the physical stresses associated with lifting nursing home residents. The subsequent field study demonstrated highly significant reductions in resident handling injuries in a study population of 1728 full and part time nurses, across all age groups and lengths of employment. Injury rates, lost and restricted workday injury rates, and workers' compensation costs were significantly reduced after the intervention.

Agricultural Safety Promotion System

Project Period:
1995 - 1998

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North Carolina A&T
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Abstract:
This was an intervention program designed to stimulate the implementation and development of both new and existing agricultural safety and health intervention.

Impact:
The MOTASK project was the basis of a national program later adopted by the National FFA for their Partners for Safer Communities. It was a million dollar program implemented across the US by FFA chapters. The CA project had all intervention sites using the developed nursery pot handles. The fact these were later commercialized would indicate their usefulness to the industry. The NY project demonstrated farmers will make voluntary correct hazards if it would reduce worker compensation claims. This program is still running in NY and has been adopted by the workers' compensation board. The OH program still exists as an educational training for farmers and workers. It is being utilized for reducing workers' compensation costs in the state. The WI project concept of introducing and promoting interventions which have profitability and safety benefits was taken to a new group of farmers, fresh vegetable producers, under a different funding program.

Work-related Violence Against Women

Project Period:
2000 - 2002

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Co-Investigator(s):
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Abstract:
Homicide is the leading cause of injury death for women in the U.S. workplace. Additionally, an estimated 667,585 women are victims of nonfatal workplace assaults annually. The 2002 Workplace Risk Supplement was a supplemental series of questions asked of eligible National Crime Victimization Survey household members. Approximately 86.5 percent or 47,694 of the eligible respondents completed the workplace risk supplement. It was designed to capture enhanced data on workplace victimizations. The supplemental survey was conducted from January through June 2002. The data is currently being analyzed, and a summary technical report and recommendations for future analyses of data is planned for late 2005. The report will include calculation of industry and

occupation rates of victimization using data from the Current Population Survey as the source of employment information.

Impact:
Expected outcomes include peer-reviewed journal articles describing the findings of these research efforts as well as educational documents for workers, employers, labor representatives, safety and health professionals, and others for use in identifying risk factors and implementing effective prevention strategies.

Evaluating Training Interventions for Small Businesses

Project Period:
2002 - 2006

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Abstract:
This project has focused on the development, delivery, and evaluation of training modules and training approaches most effective in delivering occupational safety and health (OSH) information to small business owners. Working with small business owners associated with National Federation of Independent Businesses (NFIB), eight test modules have been created covering background information regarding injury and illness in small business establishments, setting up an overall health and safety program, hearing loss prevention, job stress, electrical safety, lifting safely, respirators, and fall prevention. Materials are in a variety of formats including fact sheets, brochures, posters, paycheck stuffers, case studies, video on VHS and DVD, and novelty items designed to raise awareness and serve as reminders. Currently, the materials are being evaluated by a convenience sample of approximately 300 small business employers recruited by study partners. Results of this study will inform future research addressing small business education and training needs.

Impact:
This project will add to the body of knowledge regarding the informational needs of small business owners and managers. Results will inform future intervention efforts targeting small businesses specifically, and informational needs of higher level decision makers in general. Study findings will be disseminated to the occupational safety and health professional community through publications and presentations, and to the small business community through less technical publications in trade magazines, the NFIB and Gates McDonald newsletters, an article in the OhioBWC magazine, and other appropriate venues. Motivating decision makers to apply scarce resources to OSH concerns is a challenging task. The results of this effort will provide some insights into how this may be accomplished.

Ergonomics Interventions in Mining

Project Period:
1998 - 2003

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Abstract:
The goals were to (1) assess mine workers' exposure to risk factors, particularly musculoskeletal disorder risk factors, and (2) to evaluate the effectiveness of ergonomics interventions. The research was planned as a two-phase effort. The first phase was completed in the fall of 2000 and consisted of exposure assessments at four mine sites. The results of these assessments were used to establish health and safety baseline data and to identify general means to reduce hazard exposures. The second phase involved the development, implementation, and evaluation of ergonomics interventions at one cooperat-

ing mine site. The results of this work demonstrated the effectiveness of ergonomics interventions in reducing mine worker exposure to risk factors and the occurrence of MSD injuries.

Impact:
The ergonomics process implemented at the Bridger Coal Company produced an active ergonomics committee backed by strong participation. The training received by management, committee members and employees has led to improved interactions between employees and management regarding their thoughts on injury prevention. Employees used their knowledge of risk factors to report concerns about their jobs and their peer's jobs. In just three years, the Bridger Coal Company has implemented an effective, proactive process to reduce exposure to MSD risk factors. As conditions change at the Bridger Mine, the process is also being modified to ensure continuing improvement and effectiveness. Instead of waiting for an injury or illness to occur prior to making changes, the Bridger Coal Company is relying upon an employee-based participative process to implement interventions that promote the well-being and comfort of its employees, and to incorporate ergonomics into many other processes affecting employee safety and health.

Homicide in Convenience Stores: An Evaluation of Prevention Strategies

Project Period:
1991 - 1997

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Key Partner(s):
Virginia Depratment of Criminal Justice Services
14 local police jurisdictions

Co-Investigator(s):
n/a

Abstract:
This project evaluated environmental designs as deterrents to robbery in order to prevent work-related fatality and disability injury among convenience store workers. A case-control study which compared the environmental designs of stores that were robbed with stores that were not robbed was conducted in three urban areas of Virginia. Convenience stores with good cash-handling procedures, with bullet-resistant shielding, located in shopping centers, located around newer buildings, located in areas where a lower percentage of single males lived, more than 2 years old, not located close to where graffiti was present, located in areas where more houses were rented, located near high value structures, and located close to multifamily housing demonstrated the lowest rates of robbery. Robberies with employee resistance, use of gun by the robber, daytime occurrence, stolen merchandise, no money taken, two or more robbers present, no or only one escape route available to the robber, no drop safe, no cash limit in the cash register, employees not trained in robbery prevention, and the age of the employee greater than 35 demonstrated increased risk for employee injury during the robbery.

Impact:
Results from this study were published in peer-reviewed journals and disseminated to all stores in the study population through a poster. Results were also shared with the National Association of Convenience Stores. A request was made from WV workers' compensation for posters describing the results of the study to disseminate during their targeted efforts at convenience stores. Numerous telephone inquiries were received requesting information from the study. A current study being conducted by DSR of trends in workplace homicide has demonstrated a significant reduction in convenience store employee homicides during the past decade.

Definition and Assessment of Engineering Noise Controls

Project Period:
2001 - 2005

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Key Partner(s):
Nevada Mining Association (NMA) - State Mining Association

International Union of Operating Engineers (IUOE) - U.S. Labor Organization

National Mining Association (NMA) - U.S. Coal Organization

United Mine Workers of America (UMWA)

Co-Investigator(s):
David Yantek
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NIOSH

Abstract:
Because of the size of the equipment that is used in mining and construction and the environment in which it is operated, workers are exposed to noise that is harmful to hearing.

Recognizing that noise control is the best way to prevent noise-induced hearing loss, this project is conducting a survey of the availability and effectiveness of noise controls to be found at mine and construction sites, and assessing the lack of noise controls, and developing a noise control prioritization, as well as developing best practice workshops and publications for dissemination in print and electronically. As a result of this project, it should be more feasible to deploy noise control in the mining and construction industries thus reducing the present noise burden carried by mine and construction workers.

Impact:
After the preliminary results of this project were presented, the Mine Safety and Health Administration (MSHA) refined its procedures for enforcing the noise rule, (30 CFR, Part 62) and issuing P-codes. MSHA also updated guidance documentation regarding the feasibility of engineering noise controls. Further, through the outputs of this project mine operators have learned what types of noise controls will provide a significant noise reduction and what controls provide little to no benefit. The operators have also been educated in basic noise control techniques which should save them money and frustration in future attempts to comply with the noise rule.

Evaluating Roadway Construction Work Zone Interventions - SRL

Project Period:
2000 - 2006

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Key Partner(s):
Washington State Department of Transportation

Co-Investigator(s):
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Abstract:
Blind areas around construction equipment are a major contributing factor in incidents involving a piece of equipment striking a worker. In highway construction, these incidents result in an average of 22 deaths per year. The Spokane Research Laboratory of NIOSH, in cooperation with the Washington State Department of Transportation, is evaluating methods to decrease these incidents. One such method uses devices that assist equipment operators in monitoring blind areas around the equipment to prevent collisions with workers or other objects. Several camera and sensor systems are available for this application. Tests were conducted with devices on dump trucks to study the effectiveness of the systems in highway work zones. Results showed that many difficulties arise when using camera and sensor systems in cold, snowy climates. And, while the operation of these systems is more reliable during the warmer months, challenges still exist in using them on equipment in congested work areas.

Impact:
Recommendations on effective technologies were presented to WSDOT and Washington State regulatory officials. The recommendations were used by WSDOT to decide which devices should be implemented on their fleet of dump trucks.

Evaluation of a Safety Training Program for the Food Service Industry

Project Period:
1997 - 2002

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Co-Investigator(s):
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Trang Nguyen, M.S.
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Leslie Stayner, Ph.D.
NIOSH

Abstract:
Outcome measures for safety training effectiveness research often do not include measures such as occupational injury experience. Effectiveness mediators also receive sparse attention. A new safety training curriculum was delivered to workers in food service facilities in three companies. A similar group received training as usual. Post-test measures were collected in both groups for one year after the training. Evidence for reduction of the injury rate associated with the new training was observed at two companies but only approached significance for one of them. Knowledge scores were not associated with lower injury rates. Almost no evidence of effects of mediators of training effectiveness was found, including no relationship between safety knowledge and injury experience. Methodological issues related to conducting a large study may have influenced these results. Although safety training apparently leads to greater knowledge and, in some cases, reduced occupational injuries, the influence of mediating variables remains to be fully explained.

Impact:
There was apparently a greater reduction in occupational injuries among the new-training facilities than the usual-training facilities. The chief contribution of this study is that greater safety knowledge was not related to reduced injuries. This parallels other research that shows that individual-level variables are not good predictors of workplace behaviors. This points safety training research toward environmental factors such as management support for use of newly learned skills in the workplace.

Impact Evaluation of NIOSH-Numbered Publications

Project Period:
2000 - 2005

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American Association of Occupational Health Nurses
American College of Occupational and Environmental Medicine
American Industrial Hygiene Association
American Society of Safety Engineers

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ORISE Fellow
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NIOSH
Alex Cohen, Ph.D.
Private Contractor

Abstract:
To evaluate the usability and delivery of its information dissemination, NIOSH, in collaboration with four professional associations, developed a customer satisfaction survey that was mailed to members of these associations. Results indicate that nearly 80% of the respondents were familiar with NIOSH or used NIOSH materials as a source of occupational safety and health information. The survey data also indicated that between 80 and 90% of the respondents agreed with statements that characterized the NIOSH communication products as being impartial, clearly written at an appropriate technical level, current, concise, relevant, easy to use, and practical. These findings indicate that NIOSH is effectively reaching the majority of these four professional target audiences with credible occupational safety and health information. In the future, similar studies will be conducted to assess the views of other stakeholder groups.

Impact:
Overall, the view of NIOSH publications and information services among respondents from the four associations was highly favorable. The survey results suggest that NIOSH could: (1) expand its outreach to the 21% of respondents who had not used NIOSH materials; (2) examine the proportion of technical to non-technical publications produced by NIOSH; (3) rework dissemination plan strategies; and (4) expand future efforts to include non-OSH professionals. As a cautionary note, the 43% of selected participants who did not respond to the survey may limit the ability to make inferences about the full population. Nonetheless, NIOSH can use the baseline response levels in this survey to target ways for continuing to improve the usefulness, relevance, and quality of its publications.

Safety for Workers' Eyes: Testing the Effectiveness of Theoretically-Based Eye Injury Prevention Messages

Project Period:
1998 - 2000

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Douglas Landsittel, PhD

Abstract:
Eye injuries are preventable with the use of safety eyewear. Exploration of the reasons why construction workers wear or don't wear safety eye-protection is important for developing effective methods to increase the use of safety glasses. The major goal of this project was to increase the use of protective eyewear among carpenters by developing theory-based safety messages tailored to workers and supervisors. Salient beliefs, attitudes, and referents including channel and source preferences were identified via focus group interviews. Data from the focus groups were used to develop pre- and post-intervention surveys, and health messages tailored to carpenters and their supervisors. Surveys addressing behavioral intentions, attitudes, normative beliefs, motivation to comply, and

perceived behavioral control regarding the use of safety eyewear were completed pre- and post-intervention of messages. Direct observation of the usage of safety eyewear to pre- and post- intervention was also conducted.

Impact:
Data showed an increased use of eye protection. This study demonstrates, to a certain degree, that theory can guide practitioners in developing safety eyewear interventions. It was shown that workers would wear their glasses when given reminders and incentives and under certain conditions such as when they performed specific tasks. This intervention appears to help workers gain control over their safety eyewear via selection and reminders. This study showed an increased usage in eye protection, especially for the worker intervention condition.

• Low-Back Disorders •

Evaluation of the Efficacy of Back Belts in Material Handling Workers

Project Period:
1993 - 1999

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Co-Investigator(s):
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NIOSH (current affiliation unknown)

Janet M. Johnston, PhD
NIOSH (now University of Pittsburgh)

Abstract:
Despite scientific uncertainties, wearing back belts to prevent costly and disabling low back injury in employees is common in the workplace. Our objective was to evaluate the effectiveness of using back belts in reducing back injury claims and low back pain. A prospective cohort study was conducted in a referred sample of 13,873 material handling employees in 160 new retail merchandise stores in 30 states which provided 9377 baseline interviews and 6311 (67%) follow-up interviews. Median follow-up was 6 ½ months with data collection ending December 1998. Adjusted incidence rates of material-handling back injury workers' compensation claims and adjusted 6-month incidence rate of self-reported back pain were calculated. In the largest prospective cohort study of back belt use, adjusted for multiple individual risk factors, neither frequent back belt use nor a store policy that required belt use was associated with reduced incidence of back injury claims or low back pain.

Impact:
The NIOSH back belt study was highlighted in the CBS evening news with Dan Rather on Dec. 5, 2000 which included an interview with (then) NIOSH Director Dr. Larry Fine. This study had extensive press coverage through an Associated Press article that appeared in about 400 newspapers nationally and a video news release.

• Mixed Exposures •

Susceptibility to Lung Infection After Mixed Dust Exposure

Project Period:
2000 - 2002

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Joseph Ma, Ph.D.
West Virginia University

Co-Investigator(s):

Abstract:
Little understanding exists about of how workers exposed to metal-containing particles of mixed composition become more susceptible to infection. Evidence verifying a potential link and an understanding of the mechanisms by which exposed workers could become susceptible to infection is incomplete. A model was established to assess the pulmonary

clearance of a bacterial agent after exposure to particulates, such as residual oil fly ash (ROFA) and welding fumes. Decrements in pulmonary clearance of bacteria after pretreatment with different metal particles were observed and were mostly due to a suppression in macrophage function. The presence of soluble metals and the complexes formed by these different metals are important in the lung defense responses observed after ROFA and welding fume exposure. The findings from this study will enable NIOSH to protect and educate workers exposed to these mixed dusts and potentially prevent adverse health effects.

Impact:
This project established an animal model to assess the potential of different metal-containing particulates to increase the susceptibility to lung infection after exposure. The results of the study greatly advanced the wealth of knowledge regarding a somewhat new area of research (i.e., effect of complex mixtures on infectious disease). In addition, the project introduces mechanistic data that may explain how workers exposed to specific metal particles may become more susceptible to pulmonary infections. Results will aid in risk assessment and the development of prevention strategies that would reduce adverse health effects.

Pulmonary, Systemic, and Dermal Effects of Welding Fume Inhalation

Project Period:
2001 - 2005

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Co-Investigator(s):
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NIOSH

Xianglin Shi, Ph.D.
NIOSH

Abstract:
Epidemiology studies indicate that large numbers of welders experience adverse health effects. Little information of the causality, dose-response, and possible underlying mechanisms exists regarding the exposure to welding fumes and the health of welders. Moreover, short-term and long-term toxicology studies using animals to assess the effects of welding fumes are incomplete. This project is addressing the problem from the design of an inhalation welding fume exposure system and characterization of the particles generated to a toxicological analysis from the molecular to whole animal level in multiple organ systems by monitoring adverse effects on airway reactivity, pulmonary infectivity, induction of carcinogenesis, and dermal irritation. Final results of the toxicology studies will provide mechanistic and dosimetric information concerning welding fume exposure and be useful for risk assessment and development of prevention strategies.

Impact:
Because of our involvement in this project, NIOSH has been looked upon as a leader in the study of the health effects associated with welding fume exposure. The welding project has been highlighted in numerous interviews and stories that have appeared in both the scientific (Science) and lay press (Forbes magazine, National Law Journal, Belleville News, and The Courier Louisiana). In addition, the PI compiled an extensive literature review on the health effects of welding as requested by the National Toxicology Program (NTP). As a result of the literature review, the welding fume generation and inhalation exposure system designed and constructed by NIOSH scientists during this project will be used as a model for future NTP long-term carcinogenicity studies, as evidenced by an Interagency Agreement with NTP to partially fund these NIOSH activities.

Vibration Effects on Pulmonary Responses to Toxic Agents

Project Period:
1999 - 2004

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W. Travis Goldsmith
NIOSH

Abstract:
The purpose of this project was to determine if whole-body vibration exacerbates the effects of toxic gases and aerosols on the respiratory system. If true, this would be an important consideration when setting workplace exposure limits. In our experiments, animals were subjected to vibration while breathing air containing ozone. The pulmonary responses of these animals were compared with animals exposed to ozone or vibration alone. Pulmonary effects were assessed by measuring changes in breathing patterns and airway resistance.

Impact:
The equipment and techniques developed for this project were used in other projects to achieve a better understanding of the effects of ozone on the airways.

Effects of Mixed Dusts on Asthma and Pulmonary Infectivity

Project Period:
2000 - 2003

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Co-Investigator(s):
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NIOSH

Jane Ma, Ph.D.
NIOSH

James Antonini, Ph.D.
NIOSH

Abstract:
Diesel exhaust is an example of a mixed exposure to gases and particles with diesel exhaust particles being composed of a carbonaceous core plus a complex mixture of absorbed organics. This study evaluated the effects of diesel exhaust exposure on a cohort of garage mechanics and in a rat model. Boilermakers are another group exposed to mixed dusts (fly ash, welding fume, and sand blasting). This project evaluated the effects of these agents on susceptibility to pulmonary infection in a rat model. Results indicate that exposure to diesel exhaust particles, residual oil fly ash, and welding fume increased the susceptibility to pulmonary infection. In contrast, acute exposure to silica enhanced bacterial killing in the lung.

Impact:
These results were of interest to the Department of Defense, which is concerned about the use of jet fuel in aircraft as well as in their fleet of vehicles. The results of diesel exhaust exposure were submitted to MSHA for consideration in setting standards for diesel emissions in mines. These data were also made available to scientists at EPA, where there is concern about the contribution of diesel exhaust to ambient air particulate levels. EPA scientists are currently conducting both animal and human studies to confirm and extend our results.

Characterization of Inorganic Dust Exposures

Project Period:
1997 - 2000

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Co-Investigator(s):
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James Stephens PhD
NIOSH

Michael Keane MS
NIOSH

Joel Harrison BS
NIOSH

Abstract:
This project and two integrated projects (Surface Chemistry Characterization of Respirable Particles and Toxic Respirable Particle Biological Surface Interactions) sought to identify surface properties and interactions controlling respirable par-

ticle expression of toxicity. Surface analysis methods were developed to determine the surface elemental composition of respirable particles in occupational exposures. Without this knowledge, current methods of exposure assessment may under-or over-estimate the true hazard of an exposure. Our laboratory developed a unique capability to determine a wide variety of parameters on a particle-by-particle basis, and to identify heretofore unrecognized or difficult-to-detect properties of respirable dusts which are controlling for disease risk and which, in some cases, are responsible for seemingly anomalous epidemiological findings. Analysis of mineral dust samples from MSHA and from Tongi Medical University were performed to determine the relationship between surface-available silica and lung fibrosis risk. Additional studies explored the surface composition of hard metal dusts.

Impact:
Two publications generated by this project have won recognition in the field of occupational safety and health research:

Machining Fluids: Study of Biological Responses

Project Period:
1996 - 2000

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Co-Investigator(s):
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Abstract:
Metal working fluids (MWFs), widely used in industry for metal cutting, drilling, shaping, lubricating, and milling, have been associated with asthma and neoplasia of the larynx, pancreas, rectum, skin and urinary bladder. To date, the effects of unused MWFs show that an increase in mast cells and total histamine in the skin exists; the MWFs penetrate the skin and cause oxidative damage in the liver and testes. The effects of unused semi-synthetic metalworking fluid on the lung and upper respiratory tract were explored using inhalation and intranasal deposition in B6C3F1 mice. Exposure to MWF caused oxidative damage of lung and testes. In combination with a vitamin E deficient diet, inhalation exposure resulted in significantly enhanced accumulation of peroxidative products compared with vitamin E deficient controls. Many occupational health concerns have arisen for workers exposed to MWFs. It has been reported earlier that occupational exposure to MWFs causes allergic and irritant contact dermatitis. We have shown that dermal exposure of female and male B6C3F1 mice to 5% MWFs for 3 months resulted in accumulation of mast cells and elevation of histamine in the skin. Topical exposure to MWFs also resulted in elevated oxidative stress in the liver of both sexes and the testes in males.

Impact:
Results indicate that exposure to MWFs can result in both adverse dermal and pulmonary effects. These data can be used to support the development of prevention strategies and control measures.

Hearing Loss Due to Mixed Exposures to Organic Solvents and Noise

Project Period:
1994 - 1998

Researcher Name:
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Co-Investigator(s):
Don Henderson, Ph.D.
SUNY Buffalo

Abstract:
The purpose of this project was two-fold: (1) to identify combinations of organic solvents and noise which produce ototraumatic interactions in the auditory system and (2) to test audiometric techniques which identify auditory dysfunctions produced by exposures to noise and solvents. In view of this, the project was been modified to complete the investigation of toluene and noise in chinchillas. Hearing function were tested pre- and post-exposure to assess changes in otoacoustic emissions and auditory evoked potential (AEP) thresholds. All exposures will meet the American Association for Laboratory Animal Science guidelines and be approved by the NIOSH/DBBS Animal Care and Use Committee.

Impact:
While this project was terminated prematurely, the findings of different rates of metabolism across species is an

important finding to assist in translating the findings from numerous animal studies into informed decisions regarding human exposure limits. This research effort has finally resulted in the funding of an R01 grant for researchers at State University of New York at Buffalo.

Risks from Emerging Hazards

Project Period:
1996 - 1999

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David Frazer, PhD
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Lori Battelli, BS, RLAT
NIOSH

Abstract:
Within the workplace environment, potential exposures are often as mixtures of potentially hazardous agents. This project contributed to identifying the potential respiratory toxicity of several occupational agents that either were mixtures or were part of workplace exposures involving multiple agents. In rats, intratracheal instillation of adipic acid caused acute lung injury which could be prevented by neutralizing the pH. Nylon flock produced inflammation and persisted within the lung for at least 30 days. Waterproofing agents containing certain fluorocarbons caused hemorrhage and cell death in the deep lung. Different abrasive blasting agents produced a spectrum of lung injury ranging from not detectable to significant inflammation, fibrosis, and cytotoxicity. Our study of abrasive blasting agents contributed to the NTP nomination and acceptance of abrasive blasting agents for NTP toxicity/carcinogenicity testing. This project was completed in 1999 but continues to be cited in recent external scientific publications and in current online resources.

Impact:
This project has had documented impact outside of NIOSH. At least 19 external research publications or external online resources (one of these is an educational document with a NIOSH author) used our work, or work based upon our work. These are listed under products as indirect products. Notably, the number of citations has increased in recent years despite completion of these studies in 1999. In addition, our studies of abrasive blasting agents contributed to the NIOSH nomination of abrasive blasting agents for testing in the National Toxicology Program. Abrasive blasting agents have recently been accepted by the National Toxicology Program for toxicity/carcinogenicity studies. The data on the waterproofing spray supported the removal of this project from the market. The study on nylon flock resulted in the addition of control systems not only in the affected plant but industry wide. Thus, this project had impact both within NIOSH and externally, and the impact appears to be increasing with time.

Particle-Induced Injury in Mixed Exposures

Project Period:
1999 - 2004

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G.V.S. Rao, PhD
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Val Vallyathan, PhD
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Mark Barger
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Abstract:
A high percentage of coal miners are cigarette smokers. Diesel engine exhaust, a common agent in coal mines, and cigarette smoke contain carcinogens classified as polycyclic aromatic hydrocarbons. The effects of coal mine dusts on the bio-activation of polycyclic aromatic hydrocarbons to carcinogens is incompletely investigated. We, therefore, examined the hypothesis: Respirable coal mine dust modifies the

pulmonary carcinogenicity of cigarette smoke and polycyclic aromatic hydrocarbons. In animals exposed to both polycyclic aromatic hydrocarbons and coal mine dust, respirable coal and crystalline silica decreased metabolic activation of polycyclic aromatic hydrocarbons by CYP1A1. CYP1A1 activity decreased with increasing inflammation and was associated with, but not caused by, particle-associated apoptosis. In addition, respirable coal and crystalline silica suppressed the activity of constitutive CYP2B1 in the rat lung and constitutive CYP2B4 activity in the rabbit lung. These findings suggest that coal mine dusts are potential modifiers of polycyclic aromatic hydrocarbon metabolism and carcinogenesis.

Impact:
This study produced two useful technical findings and confirmed that coal and silica dust modify pulmonary polycyclic aromatic hydrocarbon metabolism, a process critical to lung carcinogenesis. A technique was validated for humanely exposing mice to respirable particles, aspirated from the pharynx. Although this technique was published in 2003, it has already been used in three published NIOSH studies and it is our understanding that it is being used outside of NIOSH as well. A manuscript describing the association between autofluorescence and smoking status has been drafted and we anticipate its use in post-mortem verification of smoking status. The first paper describing mixed exposures to respirable coal dust and (-naphthoflavone was published in August 2004 with an additional paper submitted last month, and three additional manuscripts in co-author review. We anticipate that our findings will be used by basic researchers and epidemiologists investigating the pulmonary carcinogenicity of inhaled poorly-soluble respirable dusts.

Surface Program: Biological Interactions

Project Period:
2001 - 2004

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NIOSH (Fellow)

Abstract:
This project performs toxicology studies in the program-project "Respirable Particle Toxicity and Surface Properties" with two integrated projects (Particle Surface Program: Dust Characterization and Particle Surface Program: Chemistry Characterization) which study surface composition, structure, and chemistry; the program is to identify surface properties and interactions controlling respirable particle expression of toxicity. Current studies in this project concern (1) the role of lung surfactant adsorption on particle surfaces and its subsequent cellular removal in distinguishing fibrogenic dust, e.g., quartz, from non-fibrogenic but comparably cytotoxic dust, e.g., kaolin clay; (2) the role of lung surfactant adsorption on the biological availability and expression of in vitro genotoxic activities by diesel exhaust particulate material and by other nano-particulate materials; (3) the effect of surface structure on the toxicity of manufactured hard metal dusts. Before 2002 this project was designated Toxic Respirable Particle Biological Surface Interactions.

Impact:
The US Department of Energy is supporting, through IAG, the "Analysis of genotoxic activities of exhausts from mobile natural gas, diesel, and spark-ignition engines." Participation was offered: (1) to the Health Effects Institute (HEI) and Coordinating Research Council of the Engine Manufacturers Association's "Workshop on strategies to evaluate diesel emissions in the Advanced Collaborative Emissions Study (ACES) Project," 2003; (2) to the National Toxicology Program, NSF, US EPA, US Airforce Office of Scientific Research,"National Nanotoxicology Workshop, Developing approaches for evaluation of toxicological interactions of nanoscale materials," 2004; (3) to the US ATSDR: "Expert panel on health effects of asbestos and synthetic vitreous fibers: the influence of fiber length," 2002 – a response to health concerns in the 9/11 World Trade Center disaster; (4) to the US National Institute of Standards and Technology (NIST) / The American Ceramic Society - Crystalline Silica Workshop 2002; and (5) to the NTP expert panel onpotential carcinogenicity of hard metal dusts.

Asphalt Fumes: Inflammatory Effects and Pulmonary Injury

Project Period:
1996 - 2003

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Co-Investigator(s):
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Abstract:
Exposures to asphalt fumes during road paving operations have been associated with airway irritation and airway hyperreactivity in some pavers. These fumes are complex mixtures that contain both particulate and potentially toxic chemicals including PAHs. Pavers are also exposed to diesel exhaust particles (DEP), which contain about 40%, by weight, adsorbed organic compounds. Mixed exposures, such as to asphalt fumes or DEP, may result in greater pulmonary injury than exposure to a single agent. This project investigated the effects of asphalt fumes on pulmonary irritation, inflammation, airway reactivity, and lung injury in an animal model. Pulmonary injury was evaluated by measuring oxidant generation, inflammatory cytokine secretion, and alterations of xenobiotic metabolic activities in the lung. The results of these studies should aid in better understanding of the potential health hazards associated with paving asphalt fumes exposure.

Impact:
The findings from this research are of significance in relation to public health concern. One of our publications from this project,"Alteration of Pulmonary Cytochrome P-450 System: Effects of Asphalt Fume Condensate Exposure," has been included in the International Programme on Chemical Safety, Concise International Chemical Assessment Document 59.

Pulmonary and Systemic Consequences of Hard Metal Exposure

Project Period:
1996 - 1999

Researcher Name:
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NIOSH

Primary Researcher Email:
n/a (retired)

Key Partner(s):
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Co-Investigator(s):
n/a

Abstract:
Hard metal, i.e., tungsten carbide/cobalt (WC/Co), is used to fabricate cutting tools. Concern exists that exposure to hard metal will result in pulmonary disease. This project evaluated the effects of pulmonary exposure to tungsten carbide (WC), cobalt (Co), or the mixture on parameters of lung damage and inflammation. Intratracheal instillation of WC/Co (1-10 mg/100mg body weight) resulted in a dose dependent increase in lung injury, measured as edema, LDH leakage from lung cells, and albumin leakage from the pulmonary circulation. A dose-dependent inflammatory response was also noted. Results indicate that inhalation of high levels of hard metal may initiate pulmonary disease.

Impact:
Data on the dose-dependent effects of exposure to WC/Co can be used for hazard identification for hard metal and to develop prevention strategies to protect workers.

Chronic Stress and Susceptibility to Workplace Chemicals

Project Period:
1997 - 2000

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Co-Investigator(s):
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NIOSH
Stanley A. Benkovic, Ph.D.
NIOSH
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Abstract:
Stress is and will continue to be a workplace issue. Lab-based and epidemiological research is used to establish the relationship between chronic stress, molecular/cellular markers of stress, and increased susceptibility to neurotoxic chemicals. Conventional and transgenic models are used to identify biomarkers of stress allowing an examination of molecular and biochemical changes induced by chronic stress as well as an examination of the role of gender and genetics in stress responses. Human worker populations are used to establish the utility of salivary cortisol, alpha-amylase, and as-yet-unidentified biomarkers of chronic stress. The development of chronic stress biomarkers will serve to identify workers at risk for health problems associated with stress and to demonstrate the effectiveness of prevention and intervention. Biomarkers will help to determine the impact of stress on workplace problems in which the nervous system is implicated in either etiology or susceptibility (e.g., musculoskeletal disorders, contact dermatitis, etc).

Impact:
Our work has shown that stress, especially the substances released during stress, can alter the toxic response induced by both neurotoxic and dermatoxic chemicals. It highlights the importance of glucocorticoid hormones as part of the inherent response of the body to both acute and chronic stress and lends validity to the examination of this hormone in human populations as a biomarker of stress. Chronic stress may lead to pathological mishandling of these important stress hormones with a resultant impact on disease development and response to toxic substances. Population-based studies of humans in high-stress occupations such as law enforcement have been initiated to examine the relationships between survey-based assessment of stress, the biological marker of stress, cortisol and the development of cardiovascular disease and neurological disorders such as post-traumatic stress disorder.

Is the Immune System Targeted By Asphalt Fumes?

Project Period:
1997 - 2004

Researcher Name:
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Key Partner(s):
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NIEHS

Co-Investigator(s):
Nicole M. Diotte
NIOSH

Abstract:
Asphalt contains a complex mixture of organic molecules including polycyclic aromatic hydrocarbons that have been reported to cause adverse health effects. In vivo and in vitro studies were conducted to investigate the immunomodulatory actions of exposure to whole asphalt fumes as well as the vapor and aerosol components of asphalt fumes in B6C3F1 female mice. An asphalt fumes generating system was constructed which provided conditions consistent with paving exposures. Mice exposed for 3.5 hours/day for up to 10 days or the vapor components showed up to a 50% suppression of the immune responsiveness. In order to determine the component responsible, the asphalt condensate and aerosol condensate were evaluated both in vitro and in vivo. Both components demonstrated immunosuppressive activity. The in vitro studies required the addition of a metabolizing system for it full activity, suggesting that the activity comes from polycyclic aromatic hydrocarbons.

Impact:
These studies support the NIOSH studies that toxic substances found in asphalt fumes produce a number of adverse effects. At least one of the classes of chemicals is likely to be the polyaromatic hydrocarbons. Other studies in HELD demonstrated the mutagenic potential of asphalt fumes and the condensate. The Asphalt Industrial partners are familiar with these studies and encourage the use of the engineering intervention for road pavers.

Asphalt Fume Chemical Characterization & Hazard Identification

Project Period:
1991 - 2004

Researcher Name:
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CDC/NIOSH/DART

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NIOSH
Virginia Houk, Sarah Warren, Larry Claxton
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Co-Investigator(s):
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NIOSH
Dr Mankit Ho, PhD (ORISE Fellow)
NIOSH

Abstract:
This multifaceted project focused on asphalt emissions research with the following objectives (1) to identify the specific compounds or compound classes that may cause irritation and genotoxic effects, (2) to develop methods to assess exposures, (3) to foster communications between researchers, and (4) to develop documents relating to the health effects or controlling and reducing exposures. This resulted in accomplishment of the following: (1) developed a method used to fractionate samples from a previous NIOSH study to aid in the identification of the chemical components that caused tumor formation; (2) developed a protocol used to assess if the addition of crumb-rubber to asphalt caused more hazardous exposures; (3) developed three methods to assess exposures; (4) had numerous meetings and visits, and organized and chaired two public forums; and (5) developed a NIOSH Hazard Review, two NIOSH documents on reducing exposures in the roofing industry, and a Concise International Chemical Assessment Document for the WHO.

Impact:
Input was provided that resulted in the TLV for asphalt being changed from "cyclohexane solubles" to "benzene solubles or equivalent", and results from the crumb rubber asphalt study caused Congress to eliminate the mandate to use crumb rubber in asphalt (National Highway Systems Designation Act of 1995). NIOSH Methods 5042 and 5800 were used to evaluate the effectiveness of engineering controls for asphalt pavers and for asphalt roofing kettles, and NIOSH Method 5042 has come to be preferred by some industry researchers over other methods. NIOSH Method 5800 was the basis of a method developed by industry. NIOSH was invited to collaborate with industry on the evaluation of engineering control prototypes, and to serve on two committees by the Asphalt Institute to peer review industry-sponsored research proposals.
NIOSH was also invited by the WHO to serve on the 11th Concise International Chemical Assessment Documents Final Review Board.

NTP Coordination: Occupational Exposures

Project Period:
1997 - 2008

Researcher Name:
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Key Partner(s):
NIOSH
NIEHS

Co-Investigator(s):
Dennis Lynch
NIOSH

Abstract:
This project is an ongoing interagency activity that seeks to obtain support from the National Toxicology Program (NTP) to address occupational health issues. Partnerships have been established in three general areas: exposure assessment, mixture characterization, and toxicological testing. The NTP has funded exposure assessments for cellulose fibers, which has been completed; for 1-bromopropane, which is still underway; and for tungsten fibers, which has just been initiated. NTP also funded the development of a paving asphalt fume generation system and partially funded development of a robotic system for generation of welding fume. These systems provide the means for characterization of the fumes and for generating fumes for toxicological experiments. Based on recommendations made by NIOSH, the NTP is in the process of conducting toxicological tests with 1-bromopropane, nine commercial metal working fluids, and five abrasive blasting materials.

Impact:
The initial impact of the recommendations made in this project was to convince the NTP to undertake research and testing activities. The outcome of research recommended by NIOSH and funded by the NTP to date has demonstrated that cellulose fiber insulation contains primarily fibers that are non-respirable. This means that the hazard associated with exposure to cellulose insulation is comparable to a nuisance dust and can be regulated as such. The constituents of asphalt fume have been thoroughly defined and have been demonstrated to be comparable to those occurring in the field. Therefore, health effects can be assessed in the laboratory using exposures that closely mimic occupational exposures. Other research activities are still ongoing and their impact can not, as yet, be determined. Data from exposure assessments of workers and toxicity testing of occupational chemicals are critical for the development of occupational health standards and documents developed by the Institute.

Molecular Mechanisms of Disease Development with Mixed Dusts

Project Period:
1999 - 2003

Researcher Name:
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Co-Investigator(s):
n/a

Abstract:
During sand blasting of metal materials or cement cutting with hard metal saws, mixed dust aerosols of trace metals and crystalline silica are generated. At this time, the potential for synergistic interactions of such metals on silica particles is unknown. This study investigated whether such toxic interaction exists. Mixed dusts were generated by blasting pure metal plates with silica. The composition, particle size, and surface area of the respirable fraction of these generated dusts were evaluated. The toxicity of these mixed dusts was measured by monitoring: surface radical generation by the dust, inflammation and pulmonary damage after in vivo exposure, and alterations in transcription factor activity after in vitro exposure. These studies should be useful in evaluating whether such mixed dusts pose a unique health hazard. The overall goal of this project was to understand the mechanisms involved in accelerated disease development in workers occupationally exposed to mixed dust.

Impact:
From these studies, we hope to identify some markers of preclinical disease/cancer development so that disease can be detected at an early stage.

Pulmonary Responses to Occupational Dusts

Project Period:
1996 - 2000

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Co-Investigator(s):
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NIOSH

Xianglin Shi, Ph.D.
NIOSH

Donna Pack
NIOSH

Min Ding, Ph.D.
NIOSH

Abstract:
Increased mortality and morbidity rates for lung disease among workers in agricultural and construction industries have been associated with exposure to mixed dusts. This increased rate of disease is hypothesized to result from the synergistic effect of several biologically-active agents found in mixed dusts exposures. This project was designed to use in vitro and in vivo techniques to identify the potential etiologic agents causing lung injury and disease. Dust samples collected from work sites were analyzed and used in investigations of the dose-response and toxicity associated with several markers of lung injury and disease development. In vivo studies followed to document pathological responses in correlation with concentrations of different toxic agents.

Impact:
The overall outcome of these studies have provided guidelines which may be useful in development of appropriate exposure limits and preventive measures for generated dusts in construction and agricultural workplaces. Results of studies should provide NIOSH with fundamental information useful for proposing appropriate control technology to reduce dust or modification of cutting tools used in construction.

• Musculoskeletal Disorders of the Upper Extremities •

Cellular Models for the Study of Hand-Arm Vibration Syndrome

Project Period:
1999 - 2002

Researcher Name:
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Key Partner(s):
n/a

Co-Investigator(s):
n/a

Abstract:
The purpose of this project was to use a cell culture-based model to study vascular changes associated with occupational hand-arm vibration syndrome. Dermal microvascular endothelial were exposed to vibration at frequencies and acceleration levels similar to those produced by vibrating tools. Changes in the expression of factors associated with vasomotion, coagulation/fibrinolysis, and inflammation were monitored to investigate the etiology of vibration-induced injury.

Impact:
The findings of this project led to a shift in focus away from cell culture models for HAVS and toward animal and human studies.

Animal Models for the Study of Musculoskeletal Disorders & Musculoskeletal Injury Mechanisms

Project Period:
1999 - 2005

Researcher Name:
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NIOSH

Co-Investigator(s):
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NIOSH
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NIOSH
Kris Krajnak, Ph.D.
NIOSH

Abstract:
The objective of this research was to investigate various factors associated with acute and chronic strain overload injury of skeletal muscle and vibration-induced pathology using animal models. The National Occupational Research Agenda (NORA) has identified musculoskeletal disorders as a primary focus area. Novel and state-of-the-art experimental methods and models of chronic strain and overload injury and vibration have been developed. The behavioral approach represents a unique methodology that is capable of imposing physiological exposures identified in human epidemiological studies as being related to the occurrence of musculoskeletal disorders. The electrical stimulation approach provides a complementary capability; one that enables the investigation of exposure conditions in a highly controlled environment suitable for acute or longer-term exposures. Such a combination has allowed investigations of the etiology of acute and chronic muscle injury and the exposure factors that increase or mitigate injury risk.

Impact:
Our research is aimed at investigating the etiology of acute and chronic muscle injury, the factors that increase injury risk, and the biological pathways responsible for injury, repair, and adaptation. Work practice recommendations are developed to reduce the incidence of injury in the workplace. Yet there is a paucity of research aimed at understanding the mechanics of injury and repair in skeletal muscle. The aims of this research are to provide understanding of skeletal muscle injury mechanics to assist the field of occupational ergonomics in developing refined work practice recommendations that incorporate soft tissue injury mechanics. The National Research Council and Institute for Medicine recommended that tissue mechanobiology studies be conducted to determine the "skeletal muscle damage threshold" under acute and repeated loading using in vivo animal models. The results of this research also has applications beneficial to recreational and athletic endeavors.

Biodynamics of Hand-Arm System and Assessment of Hand-Transmitted Vibration

Project Period:
1999 - 2006

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Co-Investigator(s):
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NIOSH

Thomas McDowell, MSc
NIOSH

Anne Brumfield, MSc
NIOSH

Aaron Schopper, PhD
NIOSH

Abstract:
Millions of workers are occupationally exposed to hand-transmitted vibration. Many of them could develop hand-arm vibration syndrome. Although several national and international standards have been published, a reliable risk assessment method has not been established. The main purposes of this project are to evaluate the existing methodologies, to develop new vibration measures and optimum frequency weightings for quantifying the exposure, and to develop effective methods for vibration measurement, anti-vibration device evaluation, and risk assessment. Advanced laboratory and modeling approaches are used. To this end, some significant results have been generated.

Impact:
Our studies have generated some significant international impacts. We have recently been invited by Industrial Health to write a review on the recent advances in biodynamics of hand-arm system. We have also been invited to write an article on the anti-vibration glove test by Noise & Vibration Worldwide. The results of our studies are at least one of the sources that have brought about the revisions of several current international standards (e.g. ISO 10068; ISO 15731). They have significantly impacted the development of another ISO standard (ISO 15230/CD, 2005). We have added a new annex (Annex A) in its revised version.

Animal Model for the Study of Hand-Arm Vibration Syndrome

Project Period:
1999 - 2003

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Oliver Wirth
NIOSH

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Key Partner(s):
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Co-Investigator(s):
n/a

Abstract:
The purposes of this project were to develop methods for exposing laboratory animals to vibration and then explore the fundamental physiological mechanisms associated with hand arm vibration syndrome (HAVS). HAVS occurs in workers who use vibrating tools. Symptoms of HAVS include vibration white finger, numbness and paresthesia in the hands, and loss of manual dexterity. Research of the biological pathways by which HAVS develops has been limited, and this has hampered efforts to reduce its occurrence. In these experiments, different methods for exposing laboratory animals to vibration were explored. Non-invasive measures, assays of gene expression, and histological examinations were used to attempt to identify the physiological pathways that are affected by vibration.

Impact:
Although this project did not have any direct impact, the information gained resulted in significant improvements in the vibration-exposure methods. As a result, more effective animal models have been developed to more systematically investigate the underlying mechanisms of HAVS.

Hand-arm Vibration: Worker Exposure and Health Effects

Project Period:
1999 - 2004

Researcher Name:
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Co-Investigator(s):
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NIOSH

Daniel Welcome, MSc
NIOSH

Abstract:
The most effective means of controlling the hand-arm vibration syndrome is to control vibration exposure. This entails the need to accurately assess vibration magnitudes and exposure durations. It also requires appropriate selection of vibrating tools and anti-vibration devices such as anti-vibration gloves and adapters. It is also very important to monitor the development of the syndrome among workers and to determine the effectiveness of prevention strategies. The main purposes of this project are to evaluate methods of vibration measurement, tool testing, and health effect testing for field applications.

Impact:
Improvements of the several ISO standards are proposed. A practical method for assessing the effectiveness of anti-vibration gloves has received very positive response. Knowledge obtained from our studies has also helped several companies or agents to conduct vibration measurement in field.

Musculoskeletal Disorders and Innate Immune System

Project Period:
2000 - 2006

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NIOSH

Abstract:
Work-related musculoskeletal disorders, a NORA priority area, represent a variety of disorders including traumatic injuries, associated with acute or chronic inflammatory responses involved in both tissue degeneration and regeneration. Identifying the specific molecular steps involved in regulation of tissue injury and repair will provide the basis for successful diagnosis, treatment and prevention of musculoskeletal diseases. The cells of the innate immune system such as the macrophages are involved not only in attacks against invading microbes but also in body wound and repair mechanisms. Mediators released by these cells may control tissue injury and repair. Selective and time dependent modulation of the innate immune system may provide optimal resolution of skeletal muscle injury.

Impact:
Understanding the mechanisms of skeletal muscle injury and recovery at the molecular level may help in the identification, treatment and prediction of occupational diseases resulting in substantial cost savings and improved health for thousands of working Americans. Given the conflicting therapeutic results with non-steroidal anti-inflammatory drugs (NSAIDs) in the recovery after skeletal muscle injuries, these studies were specifically designed to understand the effects of various inflammatory pathways in injury/repair processes. The findings provide novel information which contributes to understanding the healing post-injury but also the regeneration in degenerative skeletal muscle diseases and post-cardiac infarction. Our published research on the role of inflammatory mediators, such as TNF and chemokines, in the injury/repair mechanisms is extensively referred to in recent scientific papers. The immunotherapeutic application for enhancing restorative injury repair may have a considerable impact in treatment of combat-related injuries.

Imaging Early Response to Occupational Exposures or Injury

Project Period:
1998 - 2001

Researcher Name:
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Lori A. Battelli, BS, RLAT
NIOSH
Jane Ma, PhD
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Patricia Schleiff, MS
NIOSH

Abstract:
This project devised and demonstrated a method for non-invasive detection of lung fibrosis, e.g., silicosis, as an early active disease process. A novel tracer was used in a positron emission tomography ("PET-Scan) rabbit animal model test to detect and localize active synthesis of collagen scar tissue in the first 5 months of disease development with 90% or greater sensitivity or specificity. This was to provide early detection of lung fibrosis to improve disease surveillance and to permit determination of the active status of disease under medical management. A magnetic resonance imaging system (MRI) was set up in NIOSH to provide advanced non-invasive imaging of animal model studies of occupational disease or injury. This work continued from United States federal government fiscal year 2002 until mid-2003 under the revised title and number 9278090. Additional information on results is found there.

Impact:
The fluoro-proline tracer PET-scan method test was completed in the subsequent project , CAN 9278890, "Imaging and grading occupational disease or injury", and published. Possible uses of a fully tested method for surveillance of public or workforce exposed to respirable materials of uncertain risk, e.g., first responders to calamitous events, were brought to the attention of the "Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers" assembled following the World Trade Centers disaster.

Imaging Early Response to Occupational Exposures or Injury

Project Period:
1998 - 2001

Researcher Name:
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David Murray, PhD
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Abstract:
This project devised and demonstrated a method for non-invasive detection of lung fibrosis, e.g., silicosis, as an early active disease process. A novel tracer was used in a positron emission tomography ("PET-Scan) rabbit animal model test to detect and localize active synthesis of collagen scar tissue in the first 5 months of disease development with 90% or greater sensitivity or specificity. This was to provide early detection of lung fibrosis to improve disease surveillance and to permit determination of the active status of disease under medical management. A magnetic resonance imaging system (MRI) was set up in NIOSH to provide advanced non-invasive imaging of animal model studies of occupational disease or injury. This work continued from United States federal government fiscal year FY2002 until mid-FY2003 under the revised title and number 9278090. Additional information on results is found there.

Impact:
The fluoro-proline tracer PET-scan method test was completed in the subsequent project , CAN 9278890, "Imaging and grading occupational disease or injury", and published. Possible uses of a fully tested method for surveillance of public or workforce exposed to respirable materials of uncertain risk, e.g., first responders to calamitous events, were brought to the attention of the "Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers" assembled following the World Trade Centers disaster.

• Organization of Work •

Health & Safety Outcomes Related to Work Schedules in Nurses

Project Period:
2000 - 2005

Researcher Name:
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NIOSH

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Key Partner(s):
American Nurses Association
University of Michigan
University of Kansas

Co-Investigator(s):
Thomas Waters
NIOSH
Tim Grosch
NIOSH
Edward Krieg
NIOSH

Abstract:
The study examines associations between work schedules (shift work and overtime) and self-reported health and safety outcomes in 1000 registered nurses employed on acute care hospital units across the United States. The study follows nurses for 12 weeks collecting an overtime diary for the 12 weeks, a 7-day sleep/activity diary, and surveys at the beginning and end of the 12-week period. Data collected from hospital records include work times, workload, and skill mix. Outcomes include gastrointestinal and cardiovascular symptoms, mood, sleep problems, automobile crashes, musculoskeletal symptoms, and needle stick injuries. The data analysis includes structure equation models to examine the relationship between work schedule characteristics and outcomes while controlling statistically for other known risk factors. The study results will contribute empirical data to improve the design of work schedules for nurses who provide direct patient care on medical-surgical or intensive care units in acute care hospitals.

Impact:
Data are currently being collected, so impact can not as yet be determined.

Work Schedule Designs to Reduce Job Strain: Evaluation of Existing Interventions

Project Period:
1997 - 2005

Researcher Name:
Claire C. Caruso, PhD, RN (PO from 2002-present)
NIOSH
Thomas Waters, PhD (PO until 2001)
NIOSH
Roger R. Rosa, PhD (PO until 2000)
NIOSH

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Key Partner(s):
Circadian Technologies

Co-Investigator(s):
n/a

Abstract:
One purpose of this project is to evaluate the effectiveness of changing work schedules to reduce risk of injury or illness due to stress and fatigue. Pre- and post-intervention data collected by external partners are being evaluated to determine which work schedules are most effective in reducing health-related problems (e.g. work absences, visits to health clinics, injury and incident rates, and changes in somatic complaints) and behavioral or psychological indices (e.g., changes in perceived stress, fatigue, rest and recovery, and satisfaction with domestic and other personal relations). Post-intervention outcomes are being compared to pre-intervention baseline values for all available measures. The second purpose of this project is to examine the state of the science concerning health and safety risks associated with long work hours.

Impact:
Bureau of Labor Statistics data show that the numbers of shift workers dropped from 18% in 1991 to 14.5% in 2001. The NIOSH educational document and research study reports may have influenced industry and labor to consider the added risks associated with 24/7 operations and influenced a move away from these demanding work schedules. In January 2004, the Federal Motor Carrier Safety Administration reduced work hours for long haul drivers. In December 2003, the Institute of Medicine released an important report, "Keeping Patients Safe", recommending work hour limits for nurses. In July 2003, the Accreditation Council for Graduate Medical Education instituted new standards requiring all U.S. residency programs to limit work hours for residents. Since 2000, 22 states have passed bills to limit mandatory overtime in health care workers and six passed their bills into law.

Work Organization and Workplace Violence

Project Period:
2002 - 2007

Researcher Name:
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Key Partner(s):
Veteran's Administration
ORC Worldwide
University of Bergen
NIOSH
National Science Foundation

Co-Investigator(s):
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NIOSH

Abstract:
The present project is an effort to examine the prevalence of both workplace psychological aggression in the U.S. and workplace violence policies and programs in place in U.S. organizations. The project is also an effort to investigate the relationship between work organization factors and workplace psychological aggression as well as the impact of workplace psychological aggression on worker health and well-being. The goal is to develop a workplace psychological aggression intervention and evaluation process that could then be used by other organizations as an aid in developing their own workplace prevention strategies.

Impact:
Survey data and the information gleaned from the expert meeting and other sources will be used to develop a fact sheet on workplace psychological aggression risk factors and prevention that can be distributed to organizations. NIOSH will also collaborate to develop a workplace psychological aggression intervention and evaluation process that could then be used by other organizations as an aid in developing their own workplace violence prevention strategies.

Work Organization Influence on Fatigue in Truck Drivers

Project Period:
2003 - 2008

Researcher Name:
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Key Partner(s):
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Dr. Michael Belzer
Wayne State University

Co-Investigator(s):
Claire Caruso, Ph.D.
NIOSH
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NIOSH

Abstract:
The purpose of this project is to examine the influence of organizational and industry factors including scheduling, economic pressure, competition, and types of freight, on fatigue and safety in commercial motor vehicle (CMV) operators. A cross-sectional survey of currently employed commercial truck drivers (n=3000) will be conducted to obtain both independent and dependent variable data. Descriptive statistics and regression modeling will be used to characterize the relationship among factors, and results will be disseminated to the trucking industry and interested academic sectors.

Impact:
Data are currently being collected, so impact cannot as yet be determined.

• Risk Assessment Methods •

Risk Assessment Methods for Particles and Fibers

Project Period:
2000 - 2010

Researcher Name:
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Abstract:
The long-term objective of this research is to provide an improved scientific basis for quantitative risk assessment of occupational exposure to respirable particles and fibers. The specific aims are to: (1) develop biologically-based dosimetry models to describe the clearance and retention kinetics of respirable particles and fibers in the lungs of animals and humans; (2) describe the dose-response relationships in each species, for both nonmalignant and malignant diseases; (3) predict disease risks in humans with working lifetime exposures; and (4) evaluate concordance of risk estimates across species. The overall impact of this project will be to enhance our understanding of key factors in the development of particle- and fiber-related lung diseases, and to use this information in risk assessment and disease prevention strategies for occupational exposure to respirable particles and fibers.

Impact:
The results of this project have contributed new knowledge that will assist in developing improved estimates of particle lung dose and disease risk in workers. The fiber models and particle and fiber data bases developed through this effort provide valuable resources for additional ongoing studies in dosimetry, epidemiology, and risk assessment. The findings from this project have furthered the development of quantitative risk assessment methods for inhaled particles. These methods may also be applicable to assessing the risks of other materials to which workers may be exposed. The results of this research will be used to more accurately assess the health impact of inhaled particles and fibers in workers and to lend further scientific support in the development of recommended exposure limits and other worker protection recommendations.

Risk Assessment Methods

Project Period:
1997 - 2007

Researcher Name:
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Abstract:
This project supports the development of new and enhanced methods for quantifying risks from occupational hazards. Risk assessments are often influential in making public health decisions, including setting NIOSH Recommended Exposure Levels (RELs) or OSHA/MSHA Permissible Exposure Levels (PELs). The methods used in risk assessments are based on modeling assumptions that are subject to considerable uncertainty. Methods development in the project has focused on improving estimates of exposure-response relationships; methods for reflecting the uncertainty of exposure information in epidemiologic studies; modeling of the exposure - internal dose relationship; evaluation of uncertainty associated with the use of physiologically-based pharmacokinetic models; methods for characterizing the risk of injuries; and methods for using epidemiologic data in risk assessment. The development of these methods serves to improve our ability to estimate quantities related to risk, and to address potentially controversial aspects of existing methods.

Impact:
This project has developed new methods which improve the quality and acceptability of risk assessment information for use in occupational recommendations and standard setting. The methods developed in this project have been used in NIOSH risk assessments that have been influential in OSHA rulemaking including 1,3-butadiene, methylene chloride and hexavalent chromium. The methods investigated under this project continue to influence the practice of risk assessment at NIOSH and in other government agencies.

Dosimetric Lung Model in Coal Miners

Project Period:
1997 - 2000

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Abstract:
To better understand the factors influencing the relationships among airborne particle exposure, lung burden, and lung disease, NIOSH and collaborating researchers developed a biologically-based kinetic model to predict the long-term retention of particles in the lungs of coal miners. This model includes alveolar, interstitial, and hilar lymph node compartments. The results show that rodent models extrapolated to humans, without adjustment for the kinetic differences in particle clearance and retention, would be inadequate for predicting lung dust burdens in humans. Also, this human lung kinetic model predicts greater retained lung dust burdens from occupational exposure than predicted from current human models based on lower exposure data. This model is useful for risk assessment of particle-induced lung diseases by estimating equivalent internal doses in rodents and humans and predicting lung burdens in humans with occupational dust exposures.

Impact:
This work contributes new knowledge to the field of dosimetry modeling. It provides a quantitative description of biological processes influencing the clearance and retention of particles in the lungs of coal miners, and has implications for workers in other dusty jobs. It also provides a quantitative basis for extrapolation of exposure-dose relationships in experimental animal studies and humans for use in risk assessment. It has been used in several follow-up studies at NIOSH and with external collaborators, and provides an important step toward better estimations of particle dose and disease risk in workers.

Gene Expression and Cell-signaling Events Associated with Toxicant-Induced Glial Activation

Project Period:
1997 - 2000

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Co-Investigator(s):
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NIOSH

Diane B. Miller, Ph.D.
NIOSH

Stanley Benkovic, Ph.D.
NIOSH

Abstract:
Laboratory-based research was conducted to establish the relationship among neurotoxicant-induced gene expression, activation of growth-associated phosphorylation cascades and astrocytic hypertrophy (a well characterized response of the central nervous system to neural injury). Changes in gene expression and in protein phosphorylation will be examined in conventional and transgenic animals as well as a brain slice preparation. The sensitivity of the observed responses to known and suspected neurotoxic chemicals (metals, organometals, substituted pyridines, substituted amphetamines, organic solvents) will be compared to the dosages/concentrations of neurotoxic agents required to engender glial activation. The utility of these models as early biomarkers of neurotoxicity in humans and their applicability for risk assessment in the workplace will ultimately be evaluated as a component of clinical studies involving neurological evaluations.

Impact:
Characterization of novel biomarkers of neurotoxicity offers the promise for subsequent development of clinically relevant tests for neurotoxic sequelae in exposed/sensitive populations and for their implementation in risk assessment programs relevant to the human population. These tests are being incorporated into routine neurotoxicity testing by regulatory agencies such as the EPA.

Risk Characterizations for Occupational Injuries

Project Period:
1996 - 1998

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Abstract:
Risk assessment models are needed for evaluating occupational injuries. A better method for measuring the impact of workplace injuries and a comparison with other workplace health hazards is desired. This project represents an opportunity for NIOSH to take the lead on assessment of injury risks shared by workers in most industries and occupations. The effects of injury, both in terms of the economic and social costs, should be measured in terms that demonstrate the consequences of life-long debilitating effects on younger workers. This project fostered research to identify those occupations with the greatest risk for injury by using a metric sensitive to the life-long consequences of injury and effects on future employment. This project incorporated a majority of NIOSH special interest areas and NORA research priorities. The essence of the project was to solicit researchers from government, academia and private industry to develop and publish contributions to risk assessment methodology.

Impact:
The impact of this effort is that an entire issue of the Human and Ecological Risk Assessment dedicated to the topic of occupational injury risk assessment underscores the increasing significance of this field of research and provides a foundation for advancing the development and application of risk assessment methodology for the prevention of occupational injuries. Over 200 copies of the special issue were distributed to researchers who requested these. Although not a part of this particular project, a second special issue of Human and Ecological Risk Assessment on the special topic of occupational injury risk assessment was published in December, 2001.

Molecular Genetics of Granulomatous Disease in Beryllium Workers

Project Period:
2001 - 2004

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NIOSH

Abstract:
Although exposure to beryllium causes chronic beryllium disease (CBD), some workers are more susceptible than others. The purpose of the project is to identify genetic determinants of CBD and investigate potential gene-gene and gene-environment interactions. Certain genes have already been implicated in increased CBD risk. For one of these, where many forms of the gene exist, a risk hierarchy is proposed; that hierarchy is being investigated here. Personal exposure and job-related exposure data are being prepared to facilitate gene-environment analyses. It is expected that the outcomes from this project will provide the basis for the development of: an animal model for CBD (transgenic animal) since no animal model currently exists; strategies for post-exposure interventions; PELs (permitted exposure levels, determined and implemented by OSHA) or exposure standards that will protect all beryllium workers.

Impact:
These data potentially become significant implications for genome-based risk assessment in occupationally related disease, especially as it relates to exposure to metals. These data also potentially have implications for the development of interventions in metal induced disease, as it relates to competitive inhibition of HLA-activated adverse immunological reactions. The observation that surface charge was associated with allelic risk hierarchy led to the choice of alleles for the development of a transgenic mouse model for CBD.

• Social & Economic Consequences •

Methods and Analysis of Economic Impact of Workplace Injury

Project Period:
1997 - 2005

Researcher Name:
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Key Partner(s):
Bureau of Labor Statistics (BLS)

Texas Workers (Compensation Commission)

Center to Protect Workers (Rights-Economic Research Network

National Safety Council (NSC)

International Association of Industrial Accident Boards and Commissions (IAI)

Co-Investigator(s):
Dan Hartley, Ed.D.
NIOSH

Abstract:
The purpose of this project is to determine the economic consequences of occupational fatal and non-fatal injuries on workers, their families, and employers that can be used to improve program planning, intervention evaluation, and policy analysis. Specific studies include developing and using a model to measure the economic burden of occupational injuries and fatalities on employers and improving the utility of an existing DSR cost of fatal occupational injuries model. Results of these studies are being made available through NIOSH documents, peer-reviewed journal articles, and analytical tools.

Impact:
The model and cost estimates have been requested by occupational safety and health organizations and researchers, cited in other research findings and publications, and used as a decision criterion in allocating government resources. Examples include: invited presentations at national and international meetings such as the 2004 Society for Mining, Metallurgy, and Exploration Annual Meeting and Exhibit (premier conference for the 13,000 members), the International Association of Industrial Accident Boards and Commissions annual meeting, and the 4th annual International Measuring the Burden of Injury conference; invited presentation at academic institutions, such as University of Utah, University of Pittsburgh, and West Virginia University; incorporation of the cost model into new cost estimates being developed by J. Paul Leigh, a preeminent economist; news coverage by the BNA Occupational Safety and Health Reporter; and as the cost model being provided to the Bolivian government for targeting occupational injury and illness prevention resources.

The Economic Burden of Occupational Illness, Injuries, and Accidents

Project Period:
1998 - 2000

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Boston University

Co-Investigator(s):
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Kenneth Sacks
NIOSH (retired)

Abstract:
Occupational illness, injuries, and accidents (OIIA) estimates are vital to setting priorities for the effective distribution of limited resources, budgeting, and for developing and implementing workplace prevention programs. OIIA numbers and cost estimates are not readily available or well understood. The purpose of this project was to provide better economic information to NIOSH, other occupational researchers, regulatory agencies, industry, and labor. Such estimates of OIIA vary depending on the methodology and data sources used. Health economists have used cost-of-illness (COI), cost-effectiveness, cost-benefit, and cost-utility analysis methods. However, in the occupational setting one is often concerned with the effect of a policy or regulation change, budget justifications, program effectiveness, and evaluating interventions. This project reviewed methods, literature, and data sources in health economics to determine appropriate methods for the economics of occupational health and safety.

Impact:
Background and discussions of methods application have been conducted with researchers and other investigators at NIOSH. Some of these recommendations have been included in a HELD Obesity proposal, an Economic Standards and Protocols project in HCRB, plus background for the Characteristics of Internet Use Project and the Feasibility of Forecasting Occupational Injuries and Illnesses – a Pilot Project; in DRDS proposals such as the Worker Exacerbation of Asthma project, the Indoor Environment Study; and in an Office of Women's Health Project. Relationships have grown internally with

toxicologists, social psychologists, epidemiologists, statisticians, and other scientific and laboratory researchers. Some of this information has been incorporated into a manuscript for immunologists. Relationships have grown with other economists at CDC such as the Health Economics Research Group, and with external researchers at Resources for the Future, Research Triangle Institute, The Institute of Medicine, EPA, and NIEHS.

Feasibility of Forecasting Occupational Injuries and Illnesses – a Pilot Project

Project Period:
2002 - 2003

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J. Paul Leigh
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Co-Investigator(s):
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Abstract:
Measuring the economic costs of occupational injuries and illnesses (OI and I) is a massive undertaking to accomplish. Measures of the number of OI and I and deaths and their impact are useful when comparing to the dollar costs of other diseases. However, numbers currently used for measuring OI and I are outdated and do not reflect advances in science, procedural alterations in data collection efforts at BLS, and changes in the workplace that have been implemented since 1992. Without this information, the impact of NORA since 1995 on the economic costs to society, employers, and workers and OIandI cannot be measured. This pilot project was to update an existing study using econometric techniques. In doing so, we intended to provide better estimates of OIandI and their economic costs for NIOSH program justifications, for NIOSH and other CDC policymakers to use in speeches and other meeting formats, and also for internal analysis as to the costs and benefits of workplace interventions.

Impact:
This was submitted as a NORA project and it was suggested that a critical mass of economists was unavailable to do this research. The Economics Forum Group was established, and it was felt that this project may be continued at a later date.

• Surveillance Research Methods •

Comparison of Two Occupational Fatality Surveillance Systems

Project Period:
1997 - 1999

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Bureau of Labor Statistics

Co-Investigator(s):
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NIOSH

Abstract:
Using different methods, two national systems compile fatal occupational injury data in the U.S.--the National Institute for Occupational Safety and Health National Traumatic Occupational Fatalities (NTOF) surveillance system and the Bureau of Labor Statistics Census of Fatal Occupational Injuries (CFOI). The NTOF uses only death certificates, while CFOI uses multiple sources for case ascertainment. Through overall and case-by-case comparisons, this study compares these systems and evaluates counts for the nation and by State for worker and case characteristics. From 1992 through 1994, NTOF reported an average of 84% of the number of traumatic occupational fatalities reported in CFOI. This percentage changed somewhat when a case-by-case comparison was conducted – 88% of the NTOF cases were matched directly to the CFOI cases. Although CFOI captured a larger number of fatalities annually, the additional fatalities did not follow a discernable pattern.

Impact:
The study results led to additional variables being added to the Census of Fatal Occupational Injury data file which provides improved research capabilities. It also supported a decision to phase out the single source NTOF system, eliminating the possibility of duplicate federally funded surveys. Furthermore, an additional study is being conducted by a major workers' compensation insurance firm and a study to compare the impact on the Gross Domestic Product from the two systems.

The Development of Nationally Standardized Occupation and Industry Coding Software

Project Period:
1991 - 2003

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National Association for Public Health Statistics and Information Systems

National Center for Health Statistics

Bureau of Labor Statistics

National Center for Chronic Disease

Prevention and Health Promotion

Bureau of the Census

Co-Investigator(s):
n/a

Abstract:
To identify worker groups that are at highest risk for fatal and non-fatal injuries, NIOSH collects occupational injury data through various sources including the National Traumatic Occupational Fatalities (NTOF) surveillance system and the National Electronic Injury Surveillance System (NEISS). Industry and occupation (I and O) information from these systems allows the association of specific health outcomes with certain industries and occupations and the identification of persons who may be at high-risk of disease or injury. Surveillance of occupational injuries and diseases requires accurate I and O information to characterize work injuries and illnesses in an effort to more directly target prevention measures. To improve these efforts, NIOSH led the development of the Standardized Occupation and Industry Coding (SOIC) software. The SOIC is a standalone Windows-based software package that assigns 3-digit numerical codes to narrative industry and occupation descriptions. This involved input from over 40 individuals representing various federal and state organizations.

Impact:
When the software was initially released in 1998, it was sent to several states to code vital records and cancer registry data. SOIC has been used to code data from NTOF, the Fatality Assessment and Control Evaluation (FACE) program, NEISS, and from the Sentinel Event Notification Systems for Occupational Risks (SENSOR).

• Traumatic Injuries •

Slips and Falls Prevention in Health Care Workers

Project Period:
2001 - 2006

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Ted Courtney, MS
Liberty Mutual Research Center for Safety and Health

Co-Investigator(s):
Sharon Chiou, PhD
NIOSH

Abstract:
The objective of this study is to develop, implement, and evaluate a slips, trips, and falls (STF) prevention program in five hospitals. A descriptive analysis of six years of pre-intervention STF injury data from the intervention hospitals will be done to provide details on the circumstances, location, and contributing factors that can be addressed by the prevention program. A laboratory study will examine the slip-resistance characteristics of 6 nursing shoes on samples of hospital flooring measured with four contaminants. This intervention will introduce the following in six hospitals: slip-resistant shoes, mats, an aggressive housekeeping program based on a written policy, audits to identify STF hazards, prompt cleaning of spills and debris, stairs and walkways kept clear, and other countermeasures. The impact of the intervention will be assessed by comparing 6-year pre-intervention with 3-year post-intervention injury experience.

Impact:
Intermediate Impacts: NIOSH conducted "walk-throughs" in the study hospitals to identify and photograph STF hazards. Recommendations to mitigate the hazards were documented in a notebook for each hospital; these notebooks were then provided to the study hospitals. Safety and health staff at

the study hospitals have been using these STF Hazard Audit notebooks to prioritize STF hazards for mitigation, and have implemented many of the recommendations presented in the notebooks.

Needlestick Injuries in Healthcare settings

Project Period:
1999 - 2001

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NIOSH

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Key Partner(s):
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The Consumer Product Safety Commission (CPSC)
42 hospital emergency departmentsIn the NEISS sample Nationwide

Co-Investigator(s):
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NIOSH

Abstract:
A surveillance study and a follow-up telephone survey were conducted: (1) to ascertain the frequency and rate of potential work-related bloodborne pathogen (BBP) exposures by industry and occupation; (2) to obtain detailed information on BBP safety training, use of personal protective equipment or safety needles, and exposure report and treatment procedures. The National Electronic Injury Surveillance System (NEISS) was used. The surveillance study suggests that while hospitals and registered nurses accounted for most of the exposures, a substantial number of exposures were also found in other industries and occupations. The survey suggests that various worker groups have unique needs that should be addressed in preventing BBP exposure in the workplace. Using safety needles can be an effective approach to prevent sharps injuries in healthcare settings, while improving awareness of the BBP standards and establishing exposure reporting and treatment procedures may be a useful first step in non-healthcare workplaces.

Impact:
Even though the results have not yet been published, more than twenty inquiries/ requests were received from state public health departments, hospitals, private infection control consultants, and research institutes in the United States and Canada after two presentations on the project were given at national meetings. The results are being used by safety and health practitioners to develop infection control plans in non-hospital settings. For example, an infection control nurse at the Texas Tech EM/EMS Division developed an infection control plan for emergency response personnel and correctional workers using the NIOSH results. Based partly on these surveillance study results, a follow-up NIOSH effort was proposed to expand BBP exposure surveillance activities to exposed workers in non-hospital settings.

Effectiveness of Collision Warning System in Large Trucks

Project Period:
2001 - 2004

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Mr. Victor A. Suski
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McKenzie Tank Lines, Inc.
Mr. David Melton
Liberty Mutual

Co-Investigator(s):
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E. Lee Husting, Ph.D.
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Abstract:
Collision warning systems (CWS) are a new technology used on motor vehicles to reduce or mitigate rear-end and side impact collisions. No evaluation of the effectiveness of CWS has been conducted using crash data. Although NIOSH has worked closely with external partners from American Trucking Associations, Liberty Mutual, trucking companies, and other governmental agencies, crash data collected directly from trucking companies were not sufficient to support a longitudinal study. The project used existing surveillance data provided by FMCSA. Crash experiences of 6,143 CWS-equipped heavy trucks were compared with the experiences of 383,058 heavy trucks without CWS. Results suggest that CWS-equipped trucks had a significantly lower proportion of crashes involving other moving vehicles and multiple vehicle crashes compared to trucks without CWS. This finding is significant because it is the first real world crash data-based evidence that suggests the design effect of CWS.

Impact:
The results of this study were the first real world crash data-based evidence to evaluate the effectiveness of CWS. Although a preliminary step, the results should be useful in sparking interest in additional application and research of CWS in the transportation industry.

Reducing Injuries from Failure of Coal Mine Roof Supports

Project Period:
1997 - 2000

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NIOSH
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NIOSH

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Key Partner(s):
n/a

Co-Investigator(s):
n/a

Abstract:
This project determined when a laser beam may be considered an ignition source for flammable materials in the mining, agriculture, telecommunications, and petrochemical industries. Laser power thresholds for igniting several flammable dusts and gases were determined experimentally. A predictive model proposed by NIOSH was evaluated. The delay time prior to ignition was recorded to aid manufacturers in the design of protective automatic shutoff systems. Knowledge gained was transferred to industry through an international working group of researchers assembled to recommend safety guidelines.

Impact:
The Analysis of Roof Bolts Systems (ARBS) primary roof support design model/guidelines and software have been introduced to the coal mining industry at a number of NIOSH Ground Control Software Workshops. The software is now being utilized by mining engineers at a number of mining operations as well as by MSHA roof control specialists to assist in the evaluate of roof control plans.

Laser Safety in Potentially Flammable Environments

Project Period:
2001 - 2004

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Instrumentation, Systems, and Automation Society (ISA)
RTP, NC
International Electrotechnical CommissionGeneva, Switzerland

Co-Investigator(s):
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NIOSH

Abstract:
The inadequacy in the selection and design of the primary roof support systems is indicated by the nearly 2,000 falls of supported roof that occur each year in underground coal mines. To reduce these roof falls, a model and guidelines to improve the design and selection or primary roof support systems was developed. This roof support design model is called Analysis of Roof Bolt Systems (ARBS). An empirical\historical approach was used to build this model where qualitative ground control data that is based on the mine's roof control experience was obtained from 119 sites in 37 mines. In the analysis, the roof fall rate is used as the criteria to evaluate the support system performance and as the dependent variable in the design model. The roof support design model is utilized through a user friendly windows based software program.

Impact:
The American National Standards Institute approved an ISA Technical Report on fiber optics used in flammable environments listing NIOSH as the lead developer. A NIOSH researcher chaired the ISA committee that produced the technical report. A NIOSH researcher is a member of an international working group of researchers that developed a draft International Electrotechnical Commission standard for optical equipment used in flammable environments. The standard has progressed to the committee draft for vote (CDV) stage.

Evaluation of a New Method for Machinery Risk Reduction

Project Period:
2001 - 2005

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Bruce Main
Designsafe Engineering
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Christensen Consulting for Safety Excellence, Ltd.

Abstract:
The project is an intervention evaluation of the new ANSI B11-TR3 Machinery Risk Assessment/Risk Reduction (RA/RR) guideline and training for its use. The TR3 intervention is being introduced into 9 companies on two machinery systems in each company. An active partnership to conduct this evaluation research jointly with qualified private sector partners was implemented in FY02. Evaluation measures include avoided injuries, reduced exposure to machinery hazards, pre-test and post-test knowledge demonstration, assessment of group processes following training, correct implementation of the guidelines, and degree to which risk reduction recommendations are implemented. The application of the validated risk assessment methodology will guide machinery designer/user teams to implement protective measures appropriate to the risk, with a resultant reduction in machinery-related injury.

Impact:
In 1995, a US safety standards consensus subcommittee (TR3) was formed under the auspices of the ANSI B11 Machine Tool Safety Standards Committee. NIOSH provided voting member expertise to this group that also includes labor, machine builder, and machine user experts. The International Standards Organization decided in 2002 to consider implementing the new US machine risk assessment practice into International standard ISO 14121 "Safety of Machinery: Risk Assessment". In January 2004, the ISO committee, with NIOSH represented, began work on a final draft of the revised standard. Both the ANSI guideline and the ISO standard provide a process that is being followed in workplaces to ensure that safety measures are appropriate to the risks in machine operation and servicing tasks.

Development of Automatic Roll Over Protective Structure (ROPS)

Project Period:
1992 - 1999
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Co-Investigator(s):
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Karl Snyder
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NIOSH

Abstract:
A spring-action, telescoping rollover protective structure and mechanism was designed and tested. These ROPS components were combined with a sensor that detects impending rollover for tractors used in agriculture. The resulting automatically deployable ROPS can provide protection on new tractors that will be operated in low overhead clearance areas such as orchards. Tractor rollovers are the most prevalent factor in fatal traumatic injury to U.S. agricultural workers. The functional components of the prototype were tested in the lab for concurrent release, time of deployment, reliable latching, compliance with ASAE S519/SAE J2194 static load tests, and ease of hydraulically resetting the structure after a deployment. Manufacturers have begun to develop the AutoROPS technology on new equipment with NIOSH assistance.

Impact:
The AutoROPS has entered a commercialization phase with industry partners from the turf care industry.

Hazard Control Evaluation of Cardboard Paper Baler Safety Device Technology

Project Period:
1995 - 1997
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Co-Investigator(s):
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Abstract:
The safeguarding technology appropriate for cardboard paper balers was comprehensively reviewed. A survey of sites and

publications on safety for balers was conducted following a team approach. The validity of laboratory testing of protective equipment on balers, or development of new safety device maintenance technology was determined. A report to a tripartite review group was developed.

Impact:
Findings from this research have been used by the standards committee that completed revisions of ANSI Z245.5 "Baling Equipment Safety" in 1999 and 2004. Users of the revised standard are municipal and commercial recycling centers. Baler manufacturers are already providing purchasers of new balers with safety equipment and safety instructions that meet the revised standard's requirements. The risk assessment study performed by NIOSH led to a decision by Congress to permit workers under the age of 18 years old to load, but not operate paper balers, particularly in grocery stores where cardboard boxes are baled for recycling. The younger workers are permitted to perform baler loading specifically if the baler has safeguards that meet the ANSI Z245.5 standard.

Evaluating Roadway Construction Work Zone Interventions

Project Period:
2001 - 2006

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Key Partner(s):
National Asphalt Pavement Association

Laborers' International Union of N. America
International Union of Operating Engineers

American Road and Trans. Builders' Assoc.

Co-Investigator(s):
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Abstract:
This ongoing, multi-disciplinary NORA research project involves laboratory and field development, demonstration, and effectiveness evaluation of selected injury prevention measures that construction contractors can use to protect workers from being struck by construction vehicles and equipment operating inside work spaces of roadway construction projects. Internal traffic control plans and proximity warning devices are the specific interventions being evaluated. While the overarching goal is to reduce fatal and serious nonfatal worker injuries among road construction workers, specific project aims are:

Impact:
NIOSH impact on worker fatalities in road construction is not anticipated for several years because the Institute is still conducting a scientific evaluation of potential injury prevention measures. Data collection will continue through 2006, with evaluation and dissemination of results planned for 2007. However, NIOSH is working with labor and industry partners, including active participation in the OSHA Roadway Work Zone Safety and Health Coalition Alliance, to accelerate the transfer of intermediate findings from the scientific evaluation to practice in the construction industry. Through this process, NIOSH and its partners are presenting preliminary findings at industry and professional meetings; developing joint publications and training materials; and working to improve safe work practices at individual construction sites. Safety consultants, labor organizations, industry trade associations, State Transportation Departments, insurance carriers, construction companies, equipment manufacturers, and OSHA offices have utilized project information to address the hazards of working around moving construction equipment.

Prevention of Violence Initiative: Research and Implementation

Project Period:
2002 - 2010

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Abstract:
The primary objective of this project is to support and coordinate the conduct of new research in the area of workplace violence prevention. Four primary goals addressed to date are: (1) to use the National Electronic Injury Surveillance System (NEISS) to conduct followback survey interviews with workers treated in hospital emergency departments for injuries related to workplace violence; (2) to conduct a supplemental interview of eligible respondents to the National Crime Victimization Survey (NCVS) related to workplace risk factors; (3) to convene a Federal Interagency Task Force on Workplace Violence Research and Prevention and share information and to identify opportunities for collaboration; and (4) to fund extramural research grants related to workplace violence prevention.

Impact:
Expected outcomes from this project include peer-reviewed journal articles describing the findings of these research efforts as well as educational documents for workers, employers, labor representatives, safety and health professionals and others with regard to identifying risk factors and implementing effective prevention strategies.

Ergonomic Evaluation of Carpenter Tasks

Project Period:
1993 - 1999

Researcher Name:
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Key Partner(s):
United Brotherhood of Carpenters Subject Recruitment

Co-Investigator(s):
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NIOSH
Hongwei Hsiao
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Scott Hendricks
NIOSH

Abstract:
This study evaluated the effect of scaffold end-frame carrying methods on worker performance, under various work conditions, to determine the best strategy to carry scaffold end frames for minimizing the risk of injuries. Three carrying methods, four types of work surfaces, two weight levels of scaffold frames, and three directions of stepping movement were tested in a laboratory with eighteen healthy construction workers. Stepping-response time, postural instability, and task difficulty rating were evaluated. Symmetric side-carrying method appeared to be the best option of the tested methods for handling the current scaffold end-frames.

Impact:
Based on the results of this project, the following recommendations were developed for ergonomic improvements to work techniques and scaffold components that may help to reduce the likelihood of fall, overexertion, and struck-by-object type injuries. Scaffold erectors are advised to adopt a symmetric side-carrying method as the primary technique and to use scaffold plank boards that have no more than a 2-inch deflection when walked across as part of the scaffold system. In an imminent hazard condition that requires a stepping action to avoid the hazard, forward- or side-stepping is more favorable than a backward stepping motion. Finally, if current scaffold end-frame weight (22 kg) can be reduced to the 9-kg level (e.g., use of reinforced light weight materials), the risk of being-struck-by-an-object, a fall, or an overexertion injury among scaffold handlers during scaffold erection and dismantling can be further minimized.

Dynamic Scaffold Modeling for Fall Protection

Project Period:
1995 - 2001

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Key Partner(s):
ROSE Manufacturing Fall protection manufacture

Co-Investigator(s):
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Abstract:
A laboratory study was conducted to determine if scaffolding has sufficient stability to serve as a fall protection anchorage in the absence of other anchorage points during scaffold erection or dismantling. Computer modeling and laboratory investigations were used to develop methods of determining the forces exerted (directions and magnitudes) on fall protection anchorage points. An anchorage point was defined as a support that is independent of the work surface, when possible, so that a collapse or fall of the work surface will not result in failure of the fall arrest equipment. Data analysis showed that using frame scaffolding as a fall protection anchorage point increases the risk of injury on the body due to the extreme forces endured (over 900 lbs.), the swing hazard created, and the potential for tipping of the entire scaffold.

Impact:
This study identifies, for the first time, magnitude and direction data previously not available in the fall and safety scientific literature, and may be useful in OSHA's non-mandatory recommendations for scaffold erector fall protection.

Harness Design and Sizing Effectiveness

Project Period:
2002 - 2006

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Abstract:
This project will develop a whole-body fall-arresting harness-sizing scheme and an improved harness design that better controls hazardous energy released during falls from elevation. Human size data, pulled from an existing database of U.S. workers and three controlled laboratory studies on harness fit to construction workers, will be used. Researchers will use 3-D anthropometry information to determine the sizing scheme and to develop torso/hip/thigh strap assemblies and rigging components that best enhance the ability of the worker to select and use the harness. The new harness system will be validated for efficacy and will be introduced into the construction workplace. The research will help the construction industry to reduce the risk of injury that results from poor user fit, improper selection, and the failure to don the protective equipment properly.

Impact:
Two harness manufacturers have signed letters of agreement with NIOSH to collaterally enhance current harness design and sizing systems to fit the current civilian population. This effort in transferring our study results into harness design practices signifies the impact of our research on real world safety practices. The new design prototypes are expected to appear within the next 10 months, and the new harness systems use a collaborative approach among workers, harness manufacturers, trade associations, safety professional societies, and NIOSH.

Evaluation of Muscle Strength Capability for Handling Large-Size Materials

Project Period:
1995 - 1998

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Co-Investigator(s):
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Abstract:
In scaffolding jobs, the limitations to safe job performance are often the result of muscular force insufficiency and balance challenges. Three experiments were conducted to address the overexertion and fall injury hazards associated with scaffold end-frame disassembly. The study evaluated a series of end-frame lifting techniques and found that a hand location between elbow height and chest height with a hand separation distance of 46 cm (using a conceptual, light-weight assistive bar) would allow workers to generate sufficient isometric strength (about twice that of the scaffold weight) to disassemble the typical 23 kg scaffolds while concurrently allowing them to mitigate the likelihood of postural imbalance.

Impact:
This project provided practical guidelines for scaffold workers to mitigate the likelihood of postural imbalance while allowing for the generation of sufficient isometric force to handle the weight of a scaffold end frame. A hand separation of 46 cm at the area between the elbow and chest heights is suggested as an optimal hand location for a conceptual assistive lifting device (e.g., a light-weight clip bar) for scaffold disassembly jobs. At least 95% of the construction population would have isometric forces in excess of the weight of scaffold end frame and also be able to mitigate the likelihood of postural imbalance. An alternative method without an assistive device would be a hand location slightly higher than the elbow height with a hand separation of 116.8 cm. This is a compromised situation that yields 2.4 times isometric strength of the scaffold weight with a little risk of postural imbalance.

Influence of Visual Cues on Work at Heights

Project Period:
1996 - 2001

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Fall protection manufacture

Co-Investigator(s):
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Abstract:
This project evaluated the adequacy of a surround screen virtual reality (SSVR) system as a human-environment-interface research tool and studied the effects of visual cues at height and restricted space on worker performance. Four experiments were performed. The participants were immersed in a virtual workplace in which they were standing or walking on an elevated scaffolding board. The height, width, and stiffness of the scaffolding board were varied. It appeared that a simulation of elevated work environment in a SSVR system, although with reduced visual fidelity, is a valid tool for safety research. Adding real planks in the SSVR virtual scaffolding model enhanced the quality of SSVR as a human-environment-interface research tool. Use of temporary level work surfaces and proximal vertical reference structures significantly reduced the destabilizing effects of height and slope on workers.

Impact:
This project laid the scientific foundation for the design of virtual environments for evaluating human performance at elevation, identifying risk factors leading to fall incidents, and assessing new fall prevention strategies. Specifically, the NIOSH SSVR system was validated to be an effective safety research tool. Adding real objects in an immersed virtual reality environment for injury prevention research is advisable to improve the realism of the environment. Individuals with limited experience working at elevation may benefit from a virtual-height training that would help to develop adequate balance control skills, before they enter an elevated construction job in order to reduce their fall risks.

Fundamental Studies of Factors Responsible for Falls of Ground

Project Period:
2002 - 2006

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Abstract:
Because the root causes of many roof falls are poorly understood, appropriate engineering and administrative controls have not always been fully used by the mining industry to anticipate and mitigate their occurrence. NIOSH is applying and developing advanced monitoring and modeling techniques to characterize the behavior of unstable ground so that a fundamental understanding of rock failure processes can be realized. Advanced monitoring techniques consist of microseismic analysis. Geologic models are being developed to catalogue the fundamental factors responsible for anomalous stress fields and variations in structural integrity of mined strata associated with failed ground. Numerical models (finite difference, discrete-element, and particle flow formulations) are being used to perform parametric studies to identify controlling failure mechanisms. The advancement of our understanding of this complex scientific problem will help to implement viable engineering controls to reduce miner exposure to falls of ground.

Impact:
This study has not yet been completed, and impact cannot as yet be measured.

Assessment of Factors Affecting Acute Eye Injury

Project Period:
1996 - 1997

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Key Partner(s):
ANSI Z87.1 Eye and Face Protection Standard Committee

Co-Investigator(s):
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NIOSH

Abstract:
This one-year pilot project was initiated to review occupational eye injury issues, develop an eyewear testing laboratory, and participate in the U.S. eye safety standards committee. Standards-setting committees rely on research conducted by partners to develop testing parameters for safety equipment. NIOSH had played a critical role in the development of testing procedures in prior versions of the eye and face protection standard.

Impact:
The pilot efforts led to (1) initiation of a new eye injury epidemiology project and later to a subcomponent of a NORA project that examined safety issues in personal protective equipment; and (2) the development of a new eyewear coverage metric. The information gained is now beginning to be incorporated into a future issue of the ANSI Z87.1 Eye and Face Protection standard.

Acute Eye Injury Epidemiology

Project Period:
1997 - 2001

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Center to Protect Workers Rights
Carpenters Union

Co-Investigator(s):
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Catherine Inman
NIOSH

Abstract:
The purpose of this project was to characterize occupational eye injuries through epidemiologic investigations of surveillance and workers' compensation data, detailed telephone interviews with injured workers, interviews and site visits with industrial groups, and assessment of safety eyewear protective equipment usage. The primary focus of the work was on understanding and preventing acute eye injuries in the construction industry. Results indicated that eye injuries account for about 5% of work-related injuries. Based on analysis of data from the National Electronic Injury Surveillance System (NEISS), more than 250,000 occupational eye injuries were treated in emergency annually. Sixteen percent of these injuries occurred to construction workers who also had the highest rate of eye injuries. A majority of the injuries were due to foreign bodies in the eye that could be prevented by appropriate use of personal protective equipment.

Impact:
Extrapolation of the number of eye injuries treated in U.S. emergency departments has led to a doubling of the estimated medically treated eye injuries that occur each day in the U.S. (~2000/day). Reduction of the prevalence of eye injuries in

the workplace has been targeted as a Healthy People 2010 goal. NIOSH data from NEISS are being used as baseline measures of eye safety improvements. The increased knowledge on eye injuries and use of eyewear has influenced recent revisions of the ANSI Z87.1 Eye and Face Protection Standard. Additionally, research into emergency department-treated eye injuries has led to an increased awareness of eye safety issues in healthcare settings, among workers exposed to avian influenza or SARS, and among emergency responders. User-friendly prevention information has been developed for these workers.

Evaluation of Emergency Service Vehicle Occupant Safety

Project Period:
2002 - 2004

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Abstract:
In collaboration with national and international partners, NIOSH combined injury surveillance data with information from field investigations to identify vehicle crash-related injury risks for emergency medical service (EMS) personnel in ambulance patient compartments. This data supported evaluation of off-the-shelf restraints that could potentially protect EMS workers during crashes and sudden movements while allowing them the mobility to attend to patients. NIOSH partnered with four occupant restraint manufacturers to evaluate restraint performance using dynamic testing techniques. Ambulance crash tests validated the sled test results, further evaluated the restraints during real crash conditions, and provided current data on the acceleration profile of ambulance patient compartments and vehicle chassis. Preliminary results have been shared with manufacturers who partnered in the testing, and with groups involved in developing specifications for ambulances.

Impact:
Continued data analysis is underway in the follow-up NIOSH project. However, the preliminary results have been disseminated to several stakeholders including NHTSA's EMS Division, the Ambulance Manufacturer's Division (AMD) of the National Truck Equipment Association (NTEA), and the General Services Administration (GSA). NHTSA has requested NIOSH participation in a national meeting that they will facilitate in July 2005 addressing ambulance safety. GSA is responsible for developing and maintaining the KKK 1822 specification for the "Star of Life Ambulance," the principal guideline for U.S. ambulance construction. GSA has requested project data and results to support improved specifications addressing ambulance safety. NTEA's AMD supports consensus guidelines regarding ambulance construction. Membership includes representatives of chassis and ambulance manufacturers, EMS transport providers, equipment manufacturers, and government. AMD currently supports the GSA KKK 1822 specification. AMD has invited NIOSH project staff to attend quarterly meetings and report project findings.

Evaluating Roadway Construction Work Zone Interventions

Project Period:
2001 - 2006

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National Asphalt Pavement Association
American Road and Trans. Builders' Assoc.
Various State Depts. of Transportation

Co-Investigator(s):
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NIOSH
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NIOSH

Abstract:
The purpose of this research is to further the field development, evaluation, and demonstration of interventions aimed at reducing worker exposure to moving vehicles and equipment operating at surface mines and inside the boundaries of work zones. Internal traffic control plans and a variety of proximity warning devices are promising, yet unproven interventions for preventing fatalities and injuries associated with mining and construction vehicles and equipment. Intervention costs, implementation problems, and worker and management acceptance of these interventions will be assessed and results will be disseminated to unions, trade associations, equipment manufacturers, MSHA, OSHA, and FHWA. If proven to be effective, adoption of these interventions throughout the surface mining and road construction industries could substantially reduce exposure of workers to moving vehicles and equipment, thus reducing fatalities and injuries related to vehicles and equipment by nearly 50%.

Impact:
NIOSH impact on traumatic worker injuries and fatalities is anticipated to be minimal for the next several years until these systems have been made into commercially available products and would then be incorporated, or retrofitted, on haul trucks and other types of surface mining and roadway construction equipment. Information dissemination of this new technology is being accomplished via presentations at conferences and articles in related journal publications. An Open Industry Briefing titled "Proximity Warning Systems for Surface Mining and Roadway Construction" is currently planned to occur in August 2006 in which sensor manufacturers, surface mining companies, and roadway construction companies will be invited to participate. Other related spin-offs of this type of proximity warning technology, once proven in practice, are expected to be developed for other types of mining, manufacturing, construction, and agricultural equipment.

Fall Prevention for Aerial Lifts in the Construction Industry

Project Period:
2002 - 2006

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Center to Protect Workers' Rights (CPWR)

Dave Merrifield, M.S.
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Mei-Li Lin, Ph.D.
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Jim Harris, M.S.
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Ren Dong, Ph.D.
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John Powers
NIOSH

Abstract:
The objective of this study is to use engineering tools and methods to redesign equipment and/or improve work practices to prevent fatalities and injuries associated with selected aerial lifts. The project first identified the most hazardous aerial lift(s) for further study. The project will now analyze the relationship between risk factors and falls when workers perform tasks while elevated, using the selected aerial lift(s). The project will also examine failure modes of aerial lifts, and further implement and assess interventions to reduce fall-related fatalities and traumatic injuries. Recommendations will be made for equipment redesign, consensus standards, and advanced technology interventions (e.g., sensors). The output from this study has the potential to impact not only construction workers, but also many other aerial lift users.

Impact:
A letter of agreement (LOA) was signed on October 7, 2004 with a leading scissor lift manufacturer – SkyJack Inc. Based on the LOA, SkyJack agreed to provide the project with a new scissor lift, an extra platform, and other critical technical and design data. This LOA provides the project with a strong collaborative partner. This interim outcome represents a step forward in the r22 process, and involves collaboration between a leading manufacturing partner and NIOSH.

A Study of Ergonomic Interventions in the Drywall Industry

Project Period:
1999 - 2004

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Abstract:
The objective of this project was to assess biomechanical stress levels using teamwork techniques to handle drywall sheets and to evaluate the usefulness of stilts to reduce fall and overexertion injuries in the construction industry. Specifically, the project assessed current interventions to reduce the contribution of ergonomic hazards to traumatic injuries in the drywall trade. This project quantified these ergonomic hazards, which were identified through both field and laboratory studies, to gain better data on those hazardous tasks, and on the activities associated with stilts and teamwork techniques. Results from this project were used to determine the usefulness of interventions for drywall handling in order to reduce ergonomic hazards and traumatic injuries.

Impact:
The findings of this project provided feasible strategies for controlling physical stresses and fall hazards in drywall-installation work, thereby promoting the safety and health of this sector of the construction population. The findings of this project were disseminated with the collaboration of the Centers to Protect Workers' Rights (CPWR), United Brotherhood of Carpenters (UBC), and International Union of Painters and Allied Trades. In addition, this study and its recommendations will be published as part of the NIOSH Workplace Solutions series to be released in 2005, with dissemination to workers nationwide. Both carpenter and painter unions expressed interest in using this Workplace Solutions document for apprentice training programs. This document not only presents the findings of a NIOSH research project in a succinct and reader-friendly manner, but does so in a way that will also directly assist workers in making good decisions about matters of safety and health and thereby reducing injury incidents.

Biomechanical Stress Control in Drywall Installation

Project Period:
1995 - 1999

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Abstract:
This field and laboratory study identified biomechanical hazards associated with drywall installation and provided possible solutions to reduce hazardous exposures. The field component included a BLS injury-database search, a video analysis of actual drywall installation, and a questionnaire to identify current drywall installation techniques and the hazardous tasks and activities associated with drywall installation. Laboratory simulation was conducted to evaluate the biomechanical stresses associated with drywall lifting and hanging. Results from this project provided recommendations on the least stressful drywall handling methods, and recommendations to reduce the biomechanical hazards resulting from overexertion and falls. Results from this study also provided further understanding and research focus for future intervention efforts on drywall-installation work, which can lead to the development of effective injury prevention and control strategies.

Impact:
The field study component has not only collected useful data from these worksites, but also established excellent collaborative opportunities and research partnerships for NIOSH. This study also represented the first large-scale, worker-based, and construction-related laboratory study, which was conducted to evaluate the biomechanical stresses associated with the lifting of large-sized manual materials. Drywall installers, carpenters, painters and construction laborers are responsible for

almost 50% of fall-related injuries in the construction industry. All of these four construction workforces handle drywall at worksites. The recommendations of this project can be extrapolated to apply and benefit the previously-mentioned four construction workforces, which represent 3.3 million construction workers. The study results were also referenced and used for wallboard-related legislative actions in Washington State in June, 2000. The study findings provided strategies for controlling physical stresses and fall hazards in drywall-installation work, thereby promoting the safety of this sector of the construction population.

Prevention of Vehicle and Mobile Equipment-related Injury

Project Period:
1998 - 1999

Researcher Name:
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Key Partner(s):
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Ken Hoffner
Laborers' Health and Safety Fund of North America

Ken Brown
3M Corporation

Janice Bradley
International Safety Equipment Association

Co-Investigator(s):
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Suzanne Marsh
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Abstract:
Work zone safety is a priority for labor, industry, and federal and state agency officials who express concern that increases in road construction and structural changes in the industry will lead to increases in worker fatalities. This project was conceived as a collaborative effort between NIOSH and stakeholders to develop a better understanding of vehicle- and equipment-related injuries, which account for over 90% of worker deaths in work zones, and to explore "best practices" solutions. Through a 3-day workshop, extensive literature and data review, and stakeholder input, NIOSH developed Building Safer Highway Work Zones, a document that offers detailed safety measures and case studies to help construction contractors and state officials protect highway workers from injury.

Impact:
A primary impact of this work is greater recognition, particularly among the government and construction industry groups that build and oversee the Nation's roads, that construction vehicles pose a substantial safety risk to pedestrian workers. At this project's inception, the Manual on Uniform Traffic Control Devices (MUTCD), the federal guideline for temporary traffic control, required that only flaggers wear high-visibility clothing. A measure that all workers in work zones wear high-visibility clothing appeared in Building Safer Highway Work Zones and in later comments on proposed rulemakings. The 2003 MUTCD revision incorporated this NIOSH measure. Building Safer Highway Work Zones continues to be a resource for the highway construction industry and has been reprinted a number of times, with almost 19,000 copies distributed to date. A number of commercial insurers distribute it to clients engaged in highway construction, and it has been adapted into training modules geared to highway workers.