



*From Research to Reality*<sup>TM</sup>

Annual Report 2001  
Liberty Mutual Research Center  
for Safety and Health

*Through its research program, in close collaboration with customers, universities, and researchers around the world, the Liberty Mutual Research Center for Safety and Health strives to accomplish its primary purpose, embodied in the Liberty Mutual Creed:*

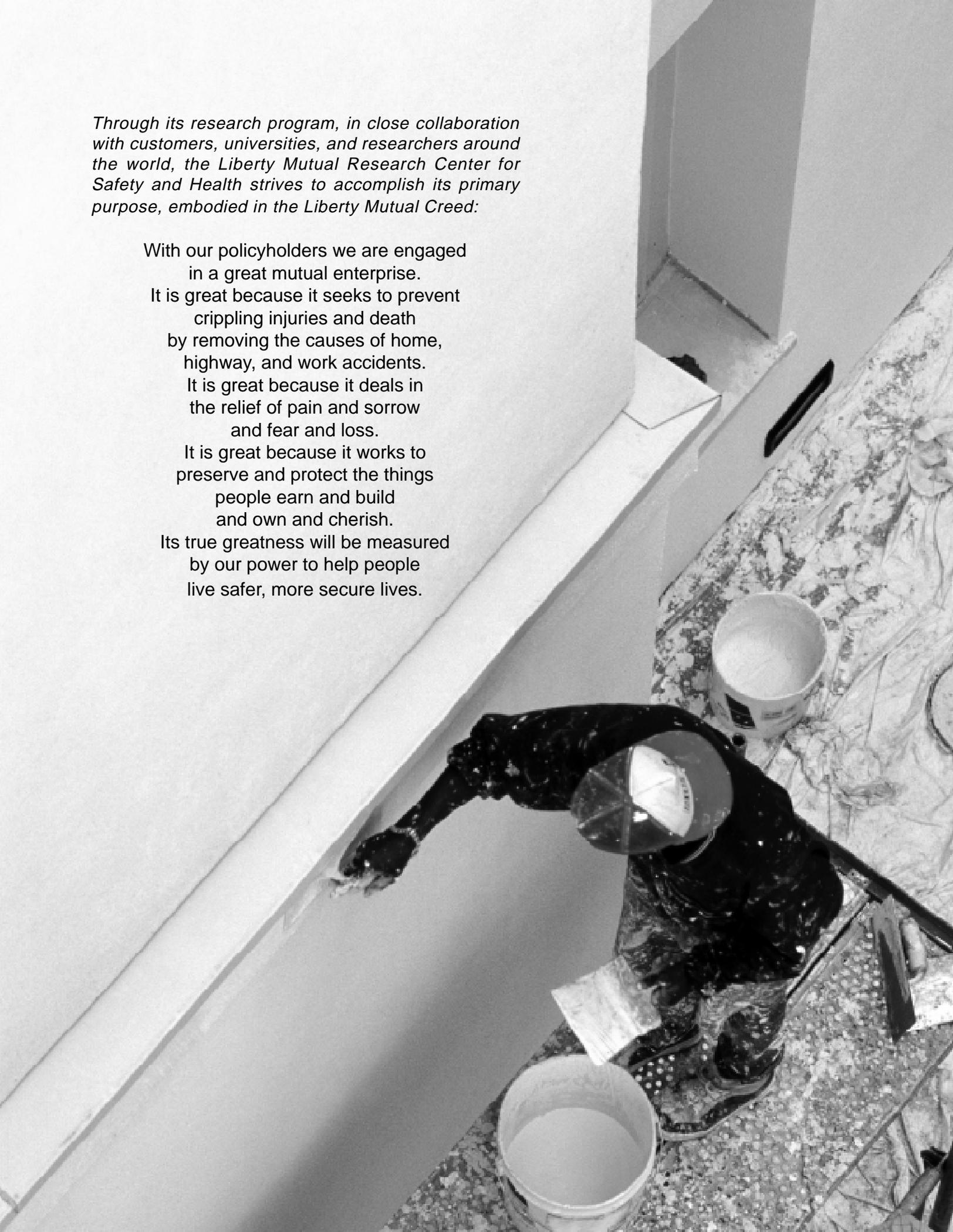
With our policyholders we are engaged  
in a great mutual enterprise.

It is great because it seeks to prevent  
crippling injuries and death  
by removing the causes of home,  
highway, and work accidents.

It is great because it deals in  
the relief of pain and sorrow  
and fear and loss.

It is great because it works to  
preserve and protect the things  
people earn and build  
and own and cherish.

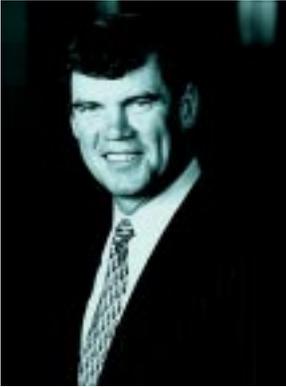
Its true greatness will be measured  
by our power to help people  
live safer, more secure lives.



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## Introduction



In 1954, Liberty Mutual dedicated a building in Hopkinton, Massachusetts to house a Research Center for Safety and Health—the only one of its kind. Almost 50 years later, the much expanded, and expanding Center continues its scientific investigations into workplace safety issues. Today's Center comprises two separate but complementary entities: the Center for Safety Research and the Center for Disability Research. Together, they embody Liberty Mutual's mission of "helping people live more secure lives."

2001 was another productive year for both Centers. The Center for Safety Research continued to investigate the leading causes of workplace injury including overexertion, slips and falls, and repetitive strain. And the Center for Disability Research stepped up its research into the causes, consequences, and prevention of disability with the introduction of four new studies.

The Research Center was active internationally as well, particularly in China, which

gained membership in the World Trade Organization in 2001. Building on our already strong ties, we co-hosted the third annual China SafeWork Forum in Shanghai, which brought together more than 150 health and safety experts and government officials from the United States and China.

We at Liberty continue to take great pride in the contributions the Research Center has made to the health and safety of our customers, their employees, and the community at large. I want to thank Tom Leamon and his colleagues at the Research Center for their dedication, hard work, and considerable achievements in 2001.

Edmund F. Kelly  
Chairman, President and  
Chief Executive Officer  
Liberty Mutual Insurance Company



The year 2001 was very productive for the Liberty Mutual Research Center for Safety and Health. Center researchers published more than 60 papers in peer-reviewed journals, and delivered more than 50 presentations around the world. Our Loss Prevention field consultants continued to benefit from the Center's scientific pursuits in occupational injury and disability.

Among the many exciting field-relevant studies currently underway are a cognitive study for safety warning processing, an examination of the impact of knife blade sharpness during meat-cutting tasks, and an investigation of the relationship between a supervisor's response to an injured worker and disability duration. And for the first time this year, Center researchers published a ranking of the 10 leading

causes of US workplace injuries. The *2001 Liberty Mutual Workplace Safety Index* will not only help drive attention to the major loss sources in US businesses, it will help our field consultants compare customer results to national trends.

I would like to congratulate the research staff on another impressive year. Speaking on behalf of the more than 600 safety and health professionals at Liberty Mutual, we appreciate their continued endeavors to help our customers' employees live safer, more secure lives.

Karl A. Jacobson  
Senior Vice President

## *From the Director*

2001 was a year of growth and new directions for the Liberty Mutual Research Center for Safety and Health. We brought several long-term strategy goals to fruition and laid the foundation for new initiatives that will enhance our research programs. We continued to demonstrate a steadfast commitment to sharing our findings worldwide through peer-review publication and interaction with the health and safety community at home and abroad.

Bringing closure to an intensive two-year recruiting effort, we were pleased to welcome Gordon Smith, MD, MPH as director of the Center for Safety Research. Prior to joining the Research Center, Dr. Smith was director of the Occupational Injury Prevention Training Program at Johns Hopkins University School of Public Health. A physician and noted epidemiologist, he brings a distinguished background of scholarly productivity and leadership at an exciting time in the Center's history.

The Research Center also welcomed six new researchers during the course of the year, further broadening our multidisciplinary research approach and global perspective. At full staff, we now employ 23 researchers whose native affiliations span four continents and nine countries, and whose areas of expertise range from epidemiology to industrial engineering to cognitive psychology.

In new research directions, the Center for Safety Research laid the groundwork for several studies including a case-crossover field investigation of slips, trips, and falls, and experimental research on human lifting patterns and repetitive upper extremity tasks involving the shoulder joint. The

Center for Disability Research continued to gain momentum with the initiation of several new studies including, a clinical investigation of low back pain treatments, and a study of factors that can contribute to re-injury.

For the first time, we hosted members of our Scientific Visitors Advisory Board for a three-day working meeting at our facility. Established in 2000 to promote the exchange of ideas on scientific quality and dissemination of findings, the Board includes directors from occupational health and safety research facilities in the United Kingdom, France, Finland, Canada, and the United States. The meeting provided an opportunity for participants to discuss mutual topics of interest including, research quality, program operations, and organizational strategies.

Complementing the staff expansion and new directions of 2001, is an equally exciting structural expansion to be completed in 2002. The construction of a new, larger facility, with state-of-the-art laboratories and administrative offices, will enable us to build upon the foundations of the past several years and better address workplace health and safety issues in the years to come.

*Tom B. Leamon .*

Tom B. Leamon, PhD  
Vice President  
Director of the Liberty  
Mutual Research Center  
for Safety and Health



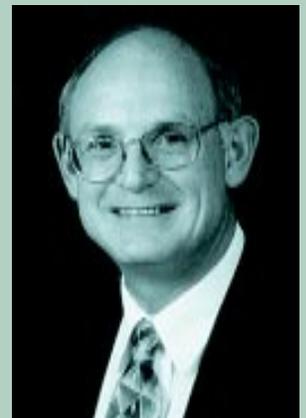


## Center for Safety Research

The Center for Safety Research investigates the causes of occupational injuries and their associated costs, and evaluates workplace demands, human capacities for various job tasks, organizational factors, and ways to advance on-the-job safety. Our multidisciplinary research approach facilitates a broad understanding of injury causes and contributes to the development of effective prevention strategies.

This year, we completed several studies including a laboratory-based comparison of industrial slipmeters, a psychophysical study of repetitive hand-tool tasks, and cognitive studies of safety symbol comprehension and in-vehicle distraction. We also made significant progress on our case-crossover study of occupational hand injuries and our analysis of National Health Interview Survey data. The addition of new research staff set the stage for new directions and further enhanced our multidisciplinary capabilities.

We continued to build on our international reputation through extensive collaboration and publication of findings in peer-reviewed journals. Of particular note was our involvement in producing special issues of three major scientific journals: *Ergonomics*, *Injury Prevention*, and the *International Journal of Occupational Safety and Ergonomics*.



Gordon S. Smith, MD, MPH  
Director of Safety Research



## *Accidents and Injuries*

Through epidemiological studies, our researchers investigate the causes and distribution of workplace accidents and injuries. We apply cutting-edge methodologies and software to analyze field study data, claims information, and government statistics. The findings are used as a scientific basis for workplace safety recommendations and to help shape research agendas both within and outside the Research Center.

### **Field Studies**

Our researchers conduct field studies to obtain and analyze real life data on occupational injuries. Through on-site observations and interviews with injured workers, we learn about circumstances and conditions at the time of a work-related accident.

### ***Risk Factors for Traumatic Hand Injuries***

We continued to analyze data from our long-term case-crossover field study of acute traumatic hand injuries. A collaborative effort with the Harvard University School of Public Health, this study uses interviews from injured patients to investigate the risk and protective factors present at the time of a work-related traumatic hand injury.

With assistance from 23 local occupational health clinics, our researchers conducted phone interviews with 1,166 hand-injured workers representing a wide variety of occupations including machine trades, service, construction, manufacturing, and sales. We asked the workers to identify the circumstances just prior to injury and to provide open-ended descriptions of how the injury occurred. In most cases, patients were interviewed within two days of the injury.

Preliminary analysis of the injury source data yielded several significant findings. In 74 percent of the cases involving lacerations, metal items (such as nails, metal stock, and burrs) or bladed hand tools (such as utility knives and razors) were the source of the injury. Thirty-seven percent of crush injuries involved powered machines such as drills, slicers, presses, stackers, and folding machines. Seventy-eight percent of avulsion injuries were attributed to bladed hand tools, powered machines, and metal items.

A final analysis of the data on protective glove use indicated that wearing gloves can reduce a worker's hand injury risk by 60 percent. In the 19 percent of cases in which workers wore gloves but

were *not* protected from injury, the glove material was not strong enough to resist the forces leading to injury. In only seven of 225 cases did glove use appear to *contribute* to injury.

### ***Risk Factors for Slips, Trips, and Falls***

According to a 1999 Bureau of Labor Statistics (BLS) report, slips, trips, and falls are a leading cause of occupational injuries among hospital workers. Second only to overexertion, these events account for 18 percent of non-fatal injuries and illnesses involving days away from work for this category of workers.

With research partners at the National Institute for Occupational Safety and Health, we began preliminary work on a long-term field investigation of slips, trips, and falls among hospital workers. The study will apply the same case-crossover methodology used in our hand injury study to identify the transient risk factors that contribute to worker falls in hospital settings.

For the pilot study, our research technicians interviewed 17 injured workers from three participating St. Louis-area hospitals. Workers were asked to provide information about the circumstances just prior to falling, including details on shoe and floor conditions. Based on

these interviews, we will examine the risk factors present at the time of the fall and compare them to exposures present in the months preceding the injury.

### **Data Studies**

Our data studies involve accessing and analyzing information from internal and national sources. The goal of this research is to identify the causes and distribution of work-related injuries and accidents both nationally and within specific industries. Occupational health and safety practitioners and researchers use our findings as a basis for making decisions, prioritizing, and establishing goals.

### ***Workplace Safety Index***

This year, our researchers completed and published the first-ever ranking of the leading causes of US workplace injuries. Presented in the *2001 Liberty Mutual Workplace Safety Index*, the study documents the 10 leading causes of injuries and illness, which accounted for 86 percent of the \$38.7 billion in wage and medical payments paid by employers in 1998.

According to the *Workplace Safety Index*, overexertion, falls, and being struck by an object are among the leading causes of workplace injuries that resulted in five or more days away from work. Overexertion, which includes excessive

lifting, pushing, pulling, holding, carrying, or throwing of an object, was the leading cause of injury, accounting for 25 percent of direct workers compensation costs paid in 1998. Falls on the same level came in second, followed by bodily reaction (slips without falls), falls to a lower level, and being struck by an object.

To develop the *Workplace Safety Index*, our researchers compared Liberty Mutual's 1998 workers compensation claims cost data to the workplace accident frequency information provided by the Bureau of Labor Statistics for that year. The relative proportions of each accident type were determined and applied to national estimates of workers compensation benefits costs compiled by the National Academy of Social Insurance from a broad range of workers compensation insurance companies.

### ***National Health Interview Survey***

Our researchers continued to analyze the occupational injury experience of more than 100,000 US residents as presented in National Health Interview Survey (NHIS) data. This project, initiated in 2000, examines the results of 43,000 household surveys collected by the National Center for Health Statistics in 1997 and 1998. We are drawing from the surveys

***The Research Center completed and published the first-ever ranking of the leading causes of US workplace injuries in the 2001 Liberty Mutual Workplace Safety Index.***

to create the most comprehensive analysis of US occupational injury to date, including a study on how off-the-job injuries impact the workplace.

Preliminary results indicated that among adults (18 years and over), the annual at-work injury rate was 4.7 injury episodes per 100 workers. Injury rates were highest among younger workers (aged 18-26 years) at 6.9 injury episodes per 100 workers. Rates decreased with increasing age to a low of 3.1 per 100 workers aged 55 years and older. Injury rates in males were double those of females.

One of the unique aspects of the NHIS is that it captures *all* injuries and then asks which of them occurred while working for pay. Of the estimated 392 million episodes of injury occurring annually to adults, 25 percent occurred at work. For people aged 25-36 years, 36 percent of all injuries occurred at work, whereas only nine percent of the injuries to those aged 55 and older occurred at work. The most common work-related injuries in all groups were strains and sprains, followed by open wounds, fractures, contusions, and dislocations. Fifty-five percent of all at-work injuries occurred in typical workplace settings such as factories, construction sites, or trade and service areas. The remaining 45 percent occurred in less-traditional workplaces such as streets and highways or in parking lots, health care set-

tings, and the home. This finding confirms the need to consider workplace injury prevention in a wide variety of environments.

### Disabling Injuries Among Construction Workers

According to 1996 BLS data, the construction industry has one of the highest occupational injury frequency rates in the United States. This segment of the workforce ranks second only to manufacturing in injury cases (9.9 per 100 workers per year), and second to transportation for cases involving days away from work (3.7 per 100 workers per year).

Although data on the frequency of construction injuries is readily available, less is known about the severity of these injuries in terms of disability. To address this imbalance, our researchers began a study of disabling occupational injuries based on information from 37,000 construction industry claims. We identified the leading types and sources of disabling occupational injury and, using mathematical models previously developed at the Center, examined the disability duration of specific injuries.

Preliminary findings showed the average disability duration for an injured construction worker was 53.6 days, with a median of seven days. This finding indicates that at least half of injured construction workers lost more than one week

of work as a result of their injuries. The most frequently occurring conditions were low back pain, foreign body eye injuries, and lacerations. However, the conditions with the longest disability were sudden-onset, traumatic injuries including fractures of the wrist, ankle, and foot. The exposures contributing to these injuries varied widely and included falls, being struck by equipment, and motor vehicle accidents.

### High Cost Truck Claims Analysis

We completed our narrative text analysis of high-cost truck accident claims reported in the time period from 1986-1998. Researchers used text mining software to examine the narrative descriptions of claims costing the trucking industry \$500,000 or more.

Of 167 crash claims studied, the leading causes contributing to high-cost truck crashes included use of alcohol or other drugs, poor road conditions/surfaces, excessive fatigue, and inclement weather conditions. Fifteen percent of these crashes had two or more factors. For instance, in eight of the nine cases of excessive fatigue or falling asleep, a high blood alcohol concentration or drug was found as a second contributor. Weather conditions were poor in 10 cases, and of those, poor road conditions, fatigue, and speeding were also contributing factors.

Our epidemiology researchers analyze internal and national data to identify the causes and distribution of workplace accidents and injuries.



## Publications

### ***American Industrial Hygiene Association Journal***

Antecedent Factors and Disabling Occupational Morbidity – Insights from the New Bureau of Labor Statistics Data

### ***Safety Science***

Epidemiology of Occupational Upper Extremity Acute Trauma Hand Injuries: A Literature Review

### ***Injury Prevention***

Case-Crossover Studies of Occupational Trauma: Methodological Caveats

### ***American Journal of Industrial Medicine***

A Case-Crossover Study of Occupational Hand Injuries: Methods and Initial Findings



## Workplace Demands

In every job, workers are subject to physical, organizational, and task-specific demands which, if not properly managed, can lead to injury or illness. We study workplace demands using a multidisciplinary approach that involves biomechanics, ergonomics, psychophysics, and organizational sciences. We also investigate existing interventions to assess their impact in the workplace. Findings from our studies are used to advance scientific understanding of the demands associated with specific tasks and job environments, and to generate recommendations to enhance worker safety and performance.

### Manual Materials Handling

Manual materials handling tasks such as lifting, pushing, pulling, and carrying objects can lead to overexertion, one of the leading causes of work-related injury. We continue to conduct human-centered studies to obtain and analyze information related to manual materials handling. Our goal is to provide a scientific basis for establishing job limits and designing job tasks for increased safety.

### *Characteristic Motion Patterns During Lifting*

As part of an ongoing effort to better understand the biomechanics of human lifting, we are studying workers' characteristic motion patterns during tasks that involve both a lift and a forward stepping movement. Such tasks are more common to industry than the no-step lifts used in current predictive models. This study will determine if individuals performing the same lifting task produce a consistent pattern of movement and if so, whether researchers can develop a realistic prediction model to identify job limits.

We designed a workstation that incorporates an adjustable shelf to simulate a work convey and a force plate to measure forces associated with the stepping motion. Eight subjects were outfitted with a motion tracking system and asked to complete two series of 18 lifts. Researchers recorded ground reaction forces and joint movements as subjects performed lifts in various combinations of workstation height, load weight, and lifting

speed. Three video cameras recorded the entire experiment from different angles.

Following the data collection, researchers calculated major joint trajectory movements, digitized the video footage, and began processing the force plate data. They also began to develop a computer simulation program that will predict and compare individual motion trajectories under various working conditions.

In a separate study, we compared lifting data collected using traditional motion tracking systems to data gathered with VidLiTeC™, our own on-site video-based lifting analysis software. The final data analysis revealed an acceptable range of error when researchers used VidLiTeC to predict lower back compressive forces during lifting. Based on this finding, we now know that VidLiTeC is a reasonable alternative to traditional, laboratory-based motion tracking systems for biomechanical analyses of lifting tasks.

### ***Utility Cover Lifting***

We finished data collection for our study of the demands associated with utility (manhole) cover lift-

ing tasks. The purpose of the project is to estimate the biomechanical stresses on the body as workers perform utility cover lifting tasks, and to evaluate the specific design features and overall usability of various cover lifting tools. We will use the information gained from this study to provide recommendations for safe and effective utility cover lifting.

We completed a laboratory simulation in which 12 experienced utility technicians performed 16 cover lifts using eight different tools – five of the tools had a j-hook configuration, and three were designed to provide a fulcrum. In addition to collecting anthropometric and postural movement data, researchers measured the forces and moments applied on the tools as workers performed cover lifting tasks. Researchers also surveyed workers on perceived physical exertion and overall tool usability.

Preliminary results from the laboratory study indicated that the tools with a j-hook configuration required workers to exert higher forces during cover lifting tasks. The other cover lifting tools, which provided a fulcrum, required less force. The biomechanical

analysis revealed that lower-back compressive forces were lower for the fulcrum bar lifting tools than for the j-hook-configured tools. According to the survey results, workers perceived that the j-hook tools required higher physical exertion but were easier to set up than the fulcrum bar tools.

### ***NIOSH Lifting Equation Assessment***

We continued our work with Texas Tech University to investigate the usability of and scientific assumptions behind the revised NIOSH lifting equation. During the five-year course of the study, researchers have collected information on job tasks, workplace demands, and demographics from almost 450 workers at 60 work-sites. Based on these data, we are examining the relationship between exposure, incidence, and severity of low back disorders and assessing the usability of the NIOSH lifting equation in the workplace.

This year, we focused our analysis on the usability of the NIOSH equation with respect to overall applicability. As part of the larger study, our researchers trained 30

*We study workplace demands using a multidisciplinary approach that involves biomechanics, ergonomics, psychophysics, and organizational sciences.*

health and safety consultants to use the equation to assess job tasks in the workplace. The training included instruction on how to select appropriate jobs for assessment, how to generate task descriptions, and how to measure the required job task parameters. The classes also included an interactive session in which participants practiced and measured task parameters.

The qualitative results from the training sessions indicated that safety consultants were most challenged by measuring task asymmetry, frequency, and duration. These parameters produced the most questions and were characterized by problems with definition, measurement, and calculation. This finding points to a need for extended training on each of these parameters as a basic prerequisite for applying the NIOSH lifting equation in the workplace.

In a study of the equation's usability, our researchers found that the variable nature of lifting and lowering demands found in many jobs made it difficult for consultants to apply the equation. Approximately 35 percent of 1,103 lifting and lowering tasks had at least one parameter outside of the acceptable range for proper use of the equation. In addition, a majority of workers (62.8%) reported that they regularly perform manual handling tasks (such as carrying

or pushing) that contradict the underlying assumptions of the equation.

### Slips and Falls

Slips and falls are the second leading cause of compensable loss across all industries. In an effort to better understand the mechanisms that can lead to slips and falls, our tribology researchers study interactions between shoes, contaminants, and floor surfaces. Our research in this area is aimed at finding ways to reduce slips and falls in the workplace and elsewhere.

#### *Evaluation of Friction Measurement Differences*

Safety and research professionals rely on industrial slipmeters to measure the slip resistance of workplace shoe and floor surfaces. These measurements can be useful in developing safety recommendations to help prevent job-related slips and falls. Often, however, different institutions report different measurements on the same materials despite using identical slipmeters. To help pinpoint the source of this discrepancy, we conducted a study under controlled laboratory conditions, to evaluate the performance of two commonly used slipmeters, the Brungraber Mark II and the English XL. The study investigated three factors – slip criterion (what

constitutes a “slip”), sample (the materials and surfaces being tested), and time (the timeframe during which a set of measurements is taken). By varying these three factors, our researchers were able to identify which one had the most impact on measurement variations.

Researchers used both slipmeters to measure friction between footwear and floor surfaces. They tested 16 common footwear materials and three floor surfaces (smooth stainless steel, vinyl composition, and unglazed quarry tiles). Measurements were taken under four conditions of surface contamination – dry, wet, oily, and oily wet – using slip criteria representing two extremes. The appropriate measures were taken to ensure that all material and surface combinations were identical across the samples, and that measurements were taken in the same manner for each trial.

The results of this study indicated that slip criterion had a much more significant effect on friction measurements than did time or sample variations. Differences attributed to sample variations were the least statistically significant among the three factors evaluated. Based on these findings, we concluded that a more consistent slip criterion could help reduce the differences in measurements reported by various institutions.

## Work Systems Design

Effective workplace design, whether in an office setting or in a manufacturing plant, is a critical factor for reducing workplace injuries and related disability. Our work systems design research examines the physical, technical, and organizational components of the workplace with the goal of improving employee health and safety on the job.

## Office Ergonomics Interventions

Our researchers continued to evaluate the effects of office ergonomics interventions in the workplace using a multifaceted,

field-based investigative approach. Through a combination of study techniques, we are examining the impact of ergonomic interventions on health and safety, as well as on office workers' perceptions of job environment, discomfort, and performance.

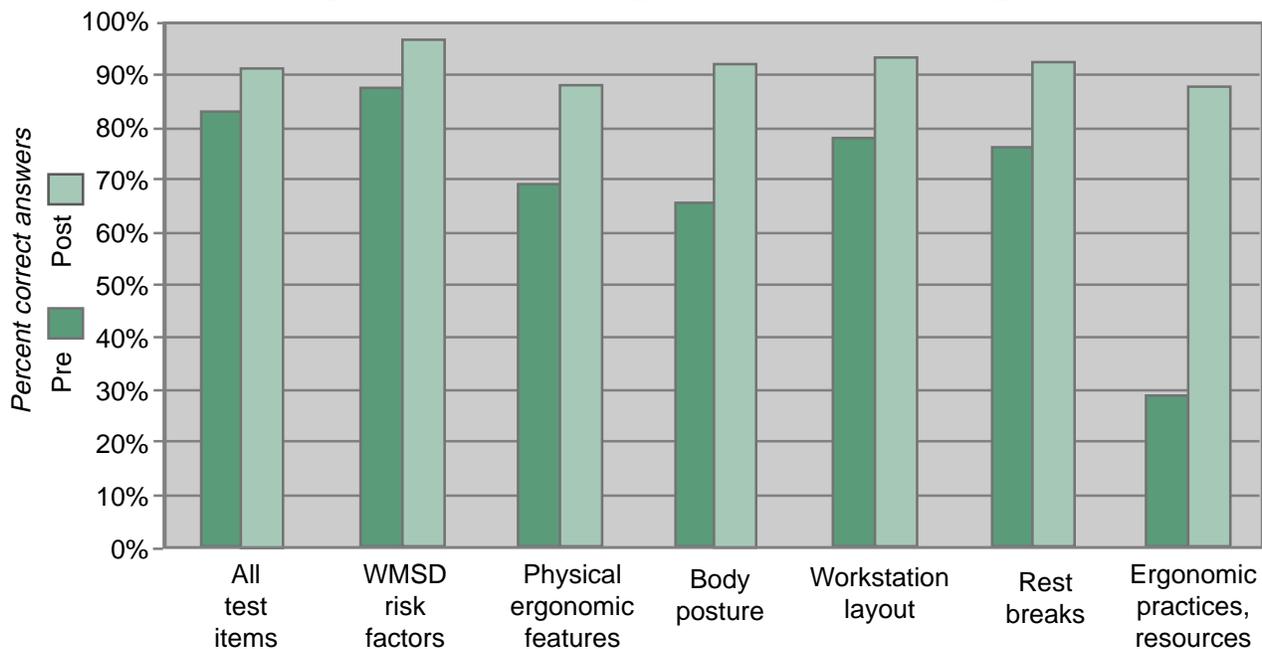
Our researchers collected data from 216 office workers employed at a large public revenue department. We divided workers into three groups and implemented different levels of ergonomic intervention for each subset of workers. The first group received ergonomics training and new workstation components; the second group received just the training; and the third subset (the

control group) did not receive any interventions.

Each of the participating workers completed a daily health diary to record their musculoskeletal and visual symptoms before and after the interventions. They were also asked to provide information on overall health, job environment satisfaction, computing habits, work role functioning, and performance. In addition, researchers observed and recorded data on workers' body postures and workstation configurations both before and after the interventions.

Preliminary results indicated a 24 percent increase in workers' overall ergonomics knowledge as a

## Office Ergonomics Training: Pre/Post Knowledge Test Results



*Office ergonomics training intervention resulted in increased knowledge in all identified ergonomic areas. Test items are grouped according to six ergonomic principles (N = 216 office workers).*

result of training. Two months following the intervention, the group that received both training and workstation changes exhibited a greater ability to adjust their workstations to accommodate more neutral body postures. This same group reported lower musculoskeletal and visual symptom levels throughout the day as compared to the other two groups. Both intervention groups reported increased workstation comfort and satisfaction as compared to the control group, which reported no change on these factors.

### ***Industrial Meat Cutting Field Investigation***

We began a long-term field study to investigate the upper extremity demands workers experience when they perform various meat-cutting tasks. The purpose of this study is twofold: to provide accurate quantification of the forces involved in meat cutting under various task conditions; and to

identify experimental variables for future hand tool research. Our findings may help us understand how to maximize job safety and performance among workers in meat packing and other industries involving extensive hand tool use.

Our researchers collected data from a total of 15 production workers at two meat packing plants. We instrumented a knife handle to collect information on grip force and cutting torque as workers performed three meat-cutting tasks – shoulder boning, rib trimming, and loin trimming. Each of the meat cutters performed his or her job with the instrumented knife preconditioned to sharp, medium, and dull levels of sharpness, representative of typical blades used at the plant.

An analysis comparing task demands to individual worker grip forces indicated that on average, the peak grip forces exerted during cutting exceeded 72 percent

of capacity. The mean grip forces sustained during cutting tasks exceeded 28 percent of capacity.

We also found that differences in blade sharpness could significantly impact the cutting moment and the grip force demands of the job. A comparison of measurements made using dull versus sharp, and medium versus sharp blades showed greater mean gripping forces, cutting torque, and time spent cutting when the duller blades were used.

**A series of biomechanical studies of typical human motion patterns during lifting will provide a scientific basis for safe task design recommendations.**



# Publications

## *Applied Ergonomics*

The Effect of  
Surface Roughness and  
Contaminant on the Dynamic  
Friction of Porcelain Tile

The Slip Resistance  
of Common Footwear  
Materials Measured  
with Two Slipmeters

Influence of Measurement  
Accuracy on the Application  
of the 1991 NIOSH Equation

## *Professional Safety*

Office Ergonomics:  
Analyzing the Problem  
and Creating Solutions

## *Journal of Biomechanics*

Biomechanical Simulation  
of Manual Lifting Using  
Spacetime Optimization



## Human Capacities

For more than 40 years, the Research Center has conducted laboratory studies to investigate human capacities and limitations for performing common work tasks. Much of this work has used psychophysical methodologies to determine the maximum acceptable workloads of selected occupational tasks. In recent years, however, the scope of our human capacities research has expanded to include biomechanical analyses and studies of human cognition, decision making, and safety perception. This multidisciplinary approach increases our understanding of the many factors – physical and psychological – that can impact worker safety and on-the-job performance.

### Psychophysical Studies

Many professions, whether in corporate offices or industrial settings, require workers to perform repetitive motions. Using a psychophysical methodology, in which human subjects perform realistic simulations of workplace tasks, our researchers gather and analyze data on perceived physical exertion. We use our findings to help employers determine maximum acceptable workloads for various studied tasks.

### *Repetitive Ulnar Deviation Tasks*

As part of an ongoing series of psychophysical studies of repetitive hand and wrist motions, we completed our investigation of an upper extremity movement involving ulnar deviation. Ulnar deviation is a sideways wrist extension movement that is comparable to the motions involved in industrial meat cutting or hammering. By increasing our understanding of what a worker can safely tolerate for upper extremity tasks involving ulnar deviation, we can use our findings to promote safer, more productive workplaces.

Using a training protocol from an earlier single-movement ulnar deviation study, our latest experiment measured the maximum acceptable torque for ulnar deviation. Two previous multi-movement studies had revealed that the maximum acceptable torque for ulnar deviation was significantly lower than it had been in the single-movement study. Therefore, we hypothesized that by using only a single-movement training protocol, the maximum acceptable torque should approach the previously obtained torque levels of the single-movement study.

Following a week of training dedicated only to the ulnar deviation movement, 14 subjects performed an ulnar deviation task for six, seven-hour workdays. For each session, subjects adjusted handle resistance to what they perceived as an acceptable level. During the first two days of the study, subjects performed the task at a repetition rate of 15 motions per minute (mpm); for the second two days they performed the task at 20 mpm; and for the final two days at 25 mpm. Subjects were asked to record the level of discomfort in their hands, wrists, and forearms at the close of each hour. As with all of our studies involving human subjects, participants gave their informed consent to the requirements of the investigation.

The experimental results revealed that, at 15 mpm, the maximum acceptable torque of ulnar deviation approached that recorded in the single-movement study. However, during the 20- and 25-mpm conditions, the maximum acceptable torque departed from the levels reported in the single-movement study and decreased as accommodation time was shortened. These results suggest that the maximum acceptable torque determined through psychophysical methods is dependent upon accommodation time, and that the

effect of experimental design (single- versus multi-movement) needs further exploration.

### ***Accuracy of Grip Force Estimates***

The grip forces required by certain hand-intensive work tasks are difficult to measure, especially when the tasks involve hand tools. Safety practitioners sometimes rely on a device known as a hand dynamometer to estimate these forces. While this device has been successfully used to measure maximum voluntary contraction, its use in estimating grip forces has not been scientifically validated. To address this issue, we began a laboratory study to compare grip force estimates made with a hand dynamometer to actual grip forces used during simulated tasks. In addition to determining the validity of these estimates, the study will provide insight into factors that may influence grip force estimates, such as skill level, force level, and type of task.

Sixteen male subjects were recruited from the general population to perform three simulated workplace tasks – a screw-driving task, a ratchet task, and a lift and carry task – at four different force levels. Our researchers used an in-house instrumented tool handle

to record actual grip forces as workers performed two repetitions of each task. Following each trial, subjects were asked to replicate the grip force applied during the task using a standard hydraulic hand dynamometer. The dynamometer was fitted with a pressure transducer to allow researchers to collect computerized data. An estimate was considered valid if the grip force was sustained for three seconds and did not vary more than  $\pm 15$  percent from the mean. Subjects repeated the estimation protocol, and when they produced two estimates averaging within 15 percent of the mean, the mean of the two values was recorded as the estimated grip force for that test condition.

The data analysis revealed a large variation among subjects in their ability to accurately estimate grip force using the hand dynamometer. Two of the subjects reported average estimates within five percent of the actual average peak grip forces. However, one subject produced estimates that were more than double the actual peak value, while another subject underestimated average grip forces by nearly one-half. When subjects were not given specific instructions about which type of force to apply, their estimation error was much smaller for peak force than

*The scope of our human capacities research has expanded to include biomechanical analyses and studies of human cognition, decision making, and safety perception.*

for average force. This finding is particularly significant as peak forces are typically used to assess job task demands during ergonomic analyses.

### ***Meat-Cutting Task Analysis***

We completed data collection for a study of the effects of workstation configuration, pace, and task complexity on worker performance of industrial meat-cutting tasks. The purpose of the study is to generate a scientific basis to help industries better control force exposures and the awkward postures that can occur during these cutting tasks.

Twelve male subjects were recruited to perform simulated industrial meat-cutting tasks for four, three-hour laboratory sessions. Subjects were outfitted with a custom-instrumented knife to measure grip forces and cutting moments, and a goniometer to measure wrist flexion and deviation. They performed cutting tasks on clay under varying conditions of work surface height and orientation, knife blade angle, job pace, and task complexity.

As subjects performed the tasks, researchers measured grip forces, cutting moments, wrist and shoulder posture, as well as other performance variables. We began reducing the data and calculating average and peak grip forces as well as cutting moments.

### ***Glenohumeral Joint Research***

Shoulder injuries, especially those involving the glenohumeral joint, are a significant concern for workers who perform repetitive tasks using the upper extremities. To address this area of concern, we began a study of the individual geometrical differences in the glenohumeral joint and their impact on injury risk. Ultimately, our findings will be used to generate a new biomechanical model of the glenohumeral joint that will be useful in injury prevention, diagnosis, and rehabilitation efforts.

With the cooperation of Massachusetts General Hospital, our researchers collected glenohumeral joint measurements from 12 male subjects using Magnetic Resonance Imaging (MRI) equipment. The subjects ranged in age from 25 to 55 years, and had never experienced chronic shoulder pain, stress fracture, or joint injury. We are currently analyzing this data, which includes information on bone surfaces, ligament lengths, joint looseness, and contact surfaces. Our findings will be incorporated into our larger laboratory study that will measure glenohumeral joint stress during simulated work tasks.

### ***Cognitive Studies***

Our cognitive studies investigate how factors such as mental workload and working memory

affect a worker's decision making, perceptions, and response times to on-the-job hazards. We are currently conducting studies which examine the effects of employee training on safety symbol comprehension, and the effects of in-vehicle distraction on driving performance.

### ***Safety Symbol Comprehension***

We completed our investigation of the effects of training and memory capacity on safety symbol comprehension. The goal of the study was to determine whether simple training programs can improve symbol comprehension and whether such programs would be differentially effective for younger versus older workers. The information gained from this study can be used to help industry maximize the efficacy of workplace warnings as a means of alerting workers to potential safety hazards.

Our researchers compared the effects of three different training conditions among younger (ages 18-35) and older (ages 50-65) subjects who were exposed to industrial safety symbols. The symbols were representative of various industries including medical, chemical, transportation, construction, and manufacturing. During the testing phase, the subject was presented with a safety symbol paired with explanatory text. He or she was asked to determine, as quickly and as accu-

rately as possible, whether the text conveyed the meaning of the symbol. Accuracy and reaction times were recorded as subjects performed computerized trials. On separate trials, the symbol was paired with a correct meaning and a plausible, but incorrect meaning. Subjects comprehended the symbol if they accepted the correct meaning *and* rejected the incorrect meaning.

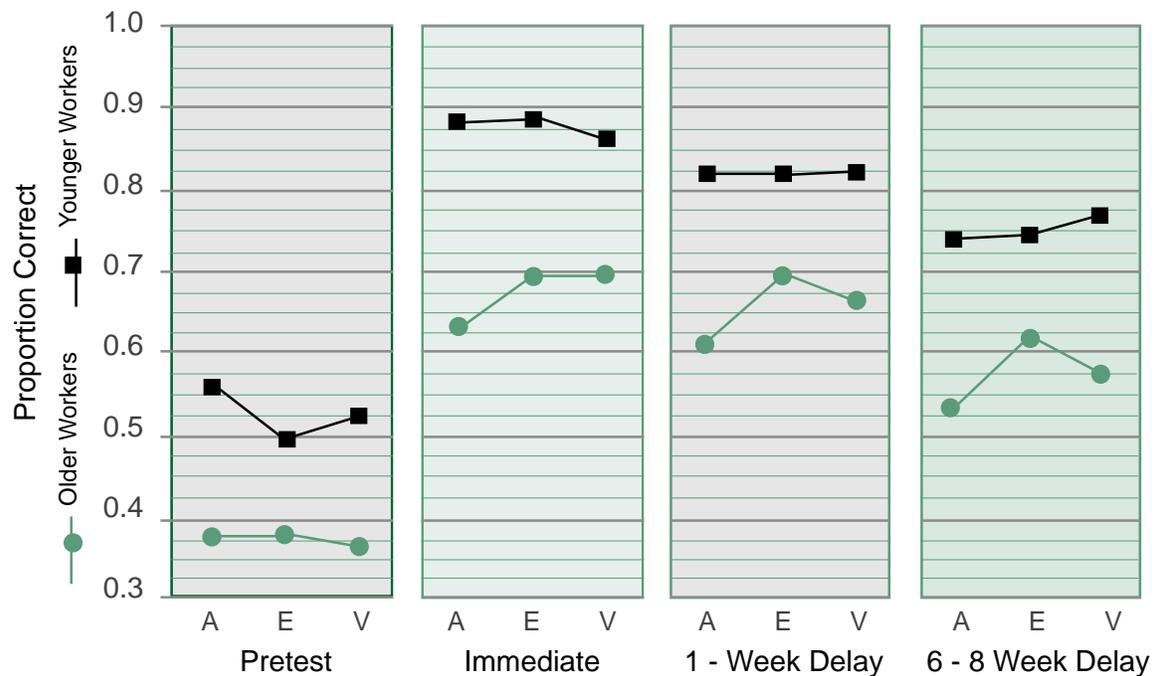
Each of the three training conditions provided an alternative memory code for the safety sym-

bol being presented. In the first condition, a simple verbal label, indicating the meaning of the symbol, was attached to the symbol. In the second condition, we paired the symbol with a brief statement explaining the nature of the hazard; and in the third condition, the symbol was paired with an accident scenario based on actual accident reports. Prior research indicates that memory functions better in these “dual coding” conditions, because if one code is lost, memory can rely on the remaining code. In total, 92 subjects were

tested at three intervals: immediately following training, one week later, and six to eight weeks later.

The data revealed extremely low symbol comprehension levels in the pre-training condition, with older subjects identifying 35 percent of the symbols accurately and younger subjects identifying 50 percent accurately. All of the subjects performed at a higher level in accepting a correct meaning of a symbol (about 70 percent correct), than in rejecting the incorrect meaning of a symbol (about 60

### Safety Symbol Comprehension as a Function of Age, Training Condition, and Session



*Younger workers comprehended safety symbols at a higher level than older workers both before and after training. Comprehension improved for both groups in each of three training conditions: accident scenario (A), explanatory statement (E), and verbal label (V).*

percent correct). Additionally, there was some indication that the older group had greater difficulty in rejecting the incorrect meaning of a symbol than the younger group, at 68 and 55 percent correct, respectively.

Training improved performance considerably from pre- to post-test for both younger and older participants. However, while younger and older participants demonstrated similar levels of learning for identifying the correct meaning of the symbol, younger participants demonstrated greater learning regarding the ability to correctly reject the incorrect meaning. This is an important finding because a concept can only be judged properly understood when the participant knows both what it is and what it is not. Regarding effectiveness, there appeared to be little difference among the training conditions.

### *Driver Distraction Research*

In follow-up to our previous study on the effects of in-vehicle distraction during critical driving maneuvers, we conducted a new investigation to determine whether the effects of in-vehicle distraction are moderated by age or gender. The new study builds upon the results of the prior study to enhance our overall understanding of how different driving situations and driver characteristics impact the use of in-vehicle

technologies. Our research findings provide a scientific basis for improving in-vehicle technologies and promoting their safe use.

As with the initial driver distraction investigation, we examined the effects of simulated cell phone use on driver response during a specified driving maneuver. This time, however, we increased the number of participants to 36 (versus 10). Nineteen drivers, ages 25-36, comprised the younger group; and 17 drivers, ages 55-65, made up the older group. Males and females were approximately equally distributed across the two age groups.

The experiment was conducted using our driving range (with a signal-equipped intersection) and an instrumented vehicle. Prior to each experimental trial (one lap around the track), drivers were required to memorize seven digits to be recalled at the end of the trial. On some trials, the light would turn red, and the drivers were instructed to treat the light change as an emergency stopping situation. Additionally, on some trials, a tone sounded as drivers approached the intersection. At that point, a simulated cell phone displayed a digit, and the driver had to decide whether the number matched the first digit of the number they had been asked to memorize. Drivers input their responses on the simulated cell phone display.

The results of this study paralleled the previous findings – when the cell phone distracter was present, drivers initiated braking more slowly but had shorter stopping times in response to the light change. This finding suggests that drivers were braking harder in an attempt to compensate for their delayed braking response. However, braking harder did not compensate for the slower response times. On average, drivers stopped 50 percent closer to the stopping line in the presence of the distracters. We also observed a 15 percent increase in non-response to the stop light in the presence of the phone distraction task.

Additionally, the effects of distraction were moderated by age such that, in the presence of distraction, older drivers initiated braking more slowly (.30 seconds slower versus .10 for younger drivers), stopped closer to the intersection (70 percent versus 20 percent closer), and were less likely to stop for the red light (22 percent reduction in compliance versus six percent for younger drivers). Although less striking, the effects of distraction were also moderated by gender; in the presence of distraction, females initiated braking about .25 seconds slower, while male subjects were .14 seconds slower. Additionally, stop light compliance fell about 25 percent for females, compared to four percent for males.

**Our studies of simulated meat-cutting tasks look at the effects of workstation configuration, pace, and task complexity on worker safety and performance.**



# Publications

## *Ergonomics*

Psychophysical Study  
of Six Hand Movements

## *Applied Ergonomics*

A System for the  
Measurement of Grip  
Forces and Applied Moments  
During Hand Tool Use

## *International Journal of Industrial Ergonomics*

The Effect of Box Size,  
Vertical Distance, and  
Height on Lowering Tasks

Maximum Acceptable  
Horizontal and Vertical  
Forces of Dynamic Pushing  
on High and Low Coefficient  
of Friction Floors



## *Center for Disability Research*

The Center for Disability Research conducts studies aimed at developing new insights into the causes, consequences, and prevention of workplace disability.

During 2001, our researchers initiated four new studies: a clinical investigation of alternative treatments for low back pain; an analysis of factors leading to reinjury; an intervention study to improve disability prevention practices; and a study to identify optimal treatments for work-related hand conditions. We enhanced our research capabilities with the introduction of an interactive voice response system which enables study volunteers to submit information via telephone. And we continued to benefit from the critical input of research collaborators, field staff, regional employers, and disability experts from around the world.

By increasing our understanding of disability and identifying methods for achieving safe and sustained return-to-work, we further our mission to improve the quality of life for all workers, especially those whose health conditions may affect their ability to work.



*Glenn Pransky, MD, MOCcH  
Director of Disability Research*



## Return to Work

At least one in eight Americans suffers a significant work disability each year, with associated costs to employers and workers for lost work time exceeding \$350 billion. It is estimated that almost half of these costs could be avoided by optimal medical management, disability prevention, and workplace accommodation strategies. By studying current clinical treatments and case management approaches to disability, our return-to-work research looks for optimal approaches to help disabled workers regain full health and function on the job. Our findings provide the scientific basis for recommendations to improve return-to-work outcomes.

### Approaches to Low Back Pain Treatment

Low back pain continues to be a major source of workers compensation indemnity and health care costs. Our recent studies examined how physician practice patterns and specific medical treatments affect patient outcomes. The insights gained from this research will allow us to help employers reduce employee lost work time due to low back pain.

### Physician Practice Patterns

We completed our study of physician practice patterns in the clinical management of low back disorders.

The study examined how physicians approach initial diagnosis and treatment of work-related low back disorders, and the extent to which they follow current medical guidelines. Information gained from the study will be used to recommend improvements in health care provider training and to better understand the practical application of science-based recommendations for treating low back pain.

Our researchers surveyed primary care physicians including internists, family and general practitioners, and emergency and occupational medicine specialists. In addition to questions regarding demographics, practice settings, and time spent treating low back pain, we asked physicians to indicate which of 25 listed interventions they would recommend in two hypothetical cases of acute onset work-related low back pain. According to the guidelines, the management of both cases should have been the same, even though one case presented more clinically relevant severe symptoms. We considered the physicians' responses to be accurate measures of their actual practice patterns.

A total of 720 physicians responded to the survey. Final data analysis revealed that emergency medicine physicians were least likely to order diagnostic studies, but more often recommended treatments

that were likely to promote inactivity (such as bed rest and/or opioid use). Occupational medicine physicians also were less likely to order diagnostic studies, but were more likely to choose treatments to promote activity (such as less bed rest, more exercise).

With respect to medical guidelines, physicians who had been in practice more than 30 years were less likely to apply the recommendations presented by the Agency for Healthcare Quality and Research (AHQR) and by the American College of Occupational and Environmental Medicine. Those who had practiced 10 years or fewer were more likely to follow the guidelines, but tended to prescribe unnecessary tests and treatments for the more severe case.

While most physician practice patterns paralleled the AHQR guidelines, in the less severe hypothetical case, a higher proportion of unnecessary tests and treatments were ordered than in the more severe case. The findings suggest physicians may be unfamiliar with or disagree with the evidence-based recommendations found in the guidelines, or they may be influenced by patient expectations for care.

### ***Intradiscal Electrothermal Therapy Outcomes***

We moved forward in our development and application of methods to evaluate emerging

treatments for work-related low back pain. One study is focusing on Intradiscal Electrothermal Therapy (IDET) for occupational low back pain. A relatively new approach to back pain therapy, IDET uses a heated probe to stabilize the intervertebral disk and eliminate nerve fibers that are the source of pain. Our investigation uses claims data to examine IDET treatment outcomes in a workers compensation population.

This year, we began to analyze 142 cases of workers who had undergone IDET treatment prior to February 2000. Among the outcomes studied were the need for narcotics, injections, or surgical procedures more than six months post IDET, and patient work status one year post IDET.

Preliminary findings indicate that the strongest predictive factors for return to work among individuals who were not working before the treatment were: being female, not having an attorney, having different physicians perform the discography and the IDET, and not using narcotics during the three months prior to receiving treatment. Younger patients were also more likely to return to work after receiving the IDET treatment.

The methods developed for this investigation can be employed to study a variety of interventions and work-related outcomes using detailed claims data.

## **Work-Related Disability Management**

Effective approaches to managing work-related disability must consider how medical, ergonomic, and psychosocial factors affect a worker's ability to return to work after an injury. Our studies in this area seek to determine what factors are most important in disability prevention and how case management can be used most effectively to improve disability outcomes.

### ***Integrated Case Disability Management***

We continued our randomized control study of integrated case management (ICM) approaches to treating occupational injuries. This study, a collaborative effort with Georgetown University and the US Department of Labor, focuses on the use of ICM approaches to treat work-related upper extremity disorders. The purpose of this investigation is to assess whether ICM, with its strong emphasis on ergonomic accommodation, training, and psychosocial factors, enhances patient recovery, well-being, and return to work.

A total of 170 injured workers from a variety of clerical and materials handling occupations were recruited for the study. Half were assigned to an ICM-trained nurse case manager, while the other half were assigned to a "usual care"

***Our return-to-work research looks for optimal approaches to help disabled workers regain full health and function on the job.***

nurse case manager. The ICM-trained nurses instructed injured workers in problem solving, ergonomic risk factor identification, and workplace accommodation. The “usual care” nurses provided a more standard approach that focused on medical care, and did not provide workers with a structured protocol for either problem solving or obtaining workplace accommodations. Participants completed surveys of pain, functional limitation, and work status at the beginning of the study and at 4-, 10-, and 16-month intervals.

A review of the baseline survey data confirmed that injured workers who were unable to resume temporary alternate or modified duty were more likely to have a diagnosis of carpal tunnel syndrome, had higher pain ratings, experienced greater functional limitation, and reported more exposure to workplace ergonomic risk factors. Factors other than pain (sleep disturbance, numbness and tingling, feeling overwhelmed, low confidence in problem solving abilities, and ergonomic risk factor exposure at work) were equally as important as pain to explain differences in the levels of reported functional limitation. These findings provided further evidence that improving function and return-to-work outcomes after work-

related upper extremity injuries may require the use of techniques to enhance pain coping, active problem solving to overcome functional barriers, and reduction of workplace ergonomic risk factor exposures.

Data collected this year has shown that the ICM approach increases the number of workplace accommodations provided for injured workers by 40 percent. Study participants reported increased satisfaction with case management services when the ICM approach was applied. This improvement can be attributed to case managers’ effectiveness in addressing a broader range of issues including physical symptoms, functional problems, medical care concerns, coping difficulties, and workplace concerns.

### *Older Workers*

We continued to collect data for our prospective investigation of work-related injuries and illnesses that occur among older workers. Through this research we are working to better understand the types of occupational injuries and illnesses among this growing segment of the workforce, as well as their typical outcomes. Ultimately, the findings from this study will be used to identify

effective interventions and return-to-work strategies to meet the unique needs of this population.

With collaborating researchers from the University of Massachusetts Medical School, we collected baseline data from 1,000 workers between the ages of 20 and 55, and 1,000 workers over age 55, within six weeks of injury. Workers provided detailed information on health, medical, demographic, economic, vocational, and social factors as well as on employer and medical responses to the injury.

Preliminary analyses of survey responses revealed a wide variety of key outcomes, including return to work, persistent pain and functional difficulties at work, job retention and job satisfaction, as well as a number of strategies that respondents felt were essential to achieving a safe and sustained return to work. As identified in previous studies, a positive employer response, along with a health care provider willing to communicate with the workplace, appeared to be essential elements in preventing disability.

**Findings from our study of integrated case management approaches showed increased satisfaction among injured workers who were assigned an ICM-trained nurse case manager.**



## Publications

### *Pain*

Working With Low Back Pain: Problem-Solving Orientation and Function

### *Southwest Journal on Aging*

Occupational Injuries and the Older Worker: Challenges in Research, Policy, and Practice

### *American Journal of Industrial Medicine*

Performance and Quality Measurement in Occupational Health Services: Current Status and Agenda for Further Research

### *American Association of Occupational Health Nurses Journal*

Case Management Services for Work-Related Upper Extremity Disorders: Integrating Workplace Accommodation and Problem Solving



## *Causes and Predictors*

Of the 5.7 million injuries and illnesses reported to the Bureau of Labor Statistics in 1999, more than one third resulted in lost work time due to days away from work. Our research on disability causes and predictors seeks to identify those factors that contribute to prolonged disability using available data, as well as survey information from patients and clinicians. By increasing our understanding of the factors that influence or precede disability, we can provide science-based recommendations for improved medical and management strategies.

### **Low Back Disability Predictors**

Because of the high prevalence and costs of work-related back injuries, they continue to be a focus of our research into how to predict and prevent disabling injuries. We use existing claims data as well as patient and clinician survey information to evaluate various factors that may contribute to low back disability.

### ***Contributing Factors to Low Back Disability***

We began data collection for a field study of factors that have been

shown to influence low back disability – such as health history, nature of work, and treatment expectations. Ultimately, the information gained from this research will be used to identify workers at highest risk for extended disability so that they can benefit from early intervention.

In cooperation with two New England occupational health clinic networks, we collected injury data from more than 400 workers who had reported a work-related back injury. Volunteers completed a three-page questionnaire when they visited a clinic within four to 10 days post-injury. They were asked about circumstances surrounding the injury, their supervisor's responses, current pain and functional impairment levels, and expectations for recovery. The treating physicians also completed a brief questionnaire.

At four to 12 weeks post-injury, patients completed a follow-up telephone survey using our interactive voice response system. This system enables the patients to call a toll-free number at their convenience, and respond to questions using the touch-tone telephone keypad.

Preliminary findings suggested that certain factors were related to prolonged disability. These factors included: shorter job tenure, greater severity of reported initial pain, self-reported functional limitations, and patient’s concern that physical activity would lead to increased pain or re-injury.

We also began a study of occupational low back injury recurrence. The study will draw from existing data to identify and examine factors – such as injury circumstances, early return to work, type and quality of initial medical care, and timing of return to work – that

may contribute to injury recurrence. The purpose of the study is to provide a scientific basis for preventive interventions, in order to improve prospects for safe and sustained return to work. We first examined several methodological challenges of prior studies, estimated how these factors would influence estimates of recurrence rates, and developed strategies for a best-practices approach to studying these events.

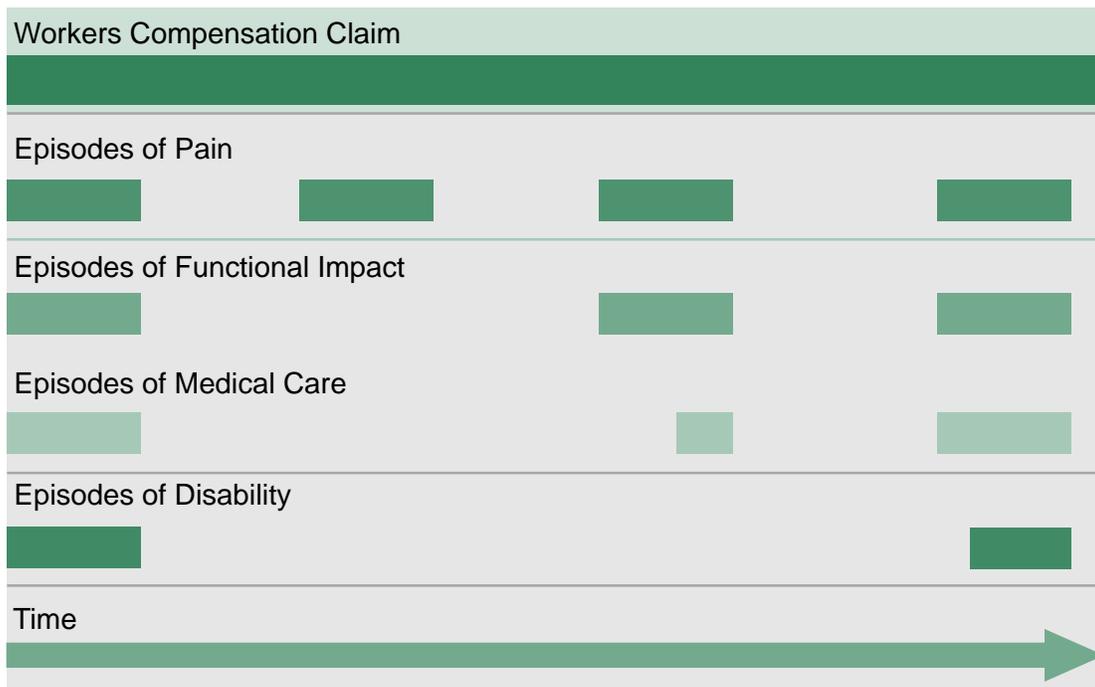
This year, we identified 2,800 disability cases of work-related low back injuries (defined as contusion, rupture, sprain, or strain)

which occurred in a single jurisdiction during a one-year period. Several analytical approaches are now being developed to identify recurrent episodes of back pain and disability.

***Risk Factors for Prolonged Disability***

We completed a retrospective cohort study of uncomplicated, work-related low back injury cases involving nurse case manager referrals. The purpose of the study was to evaluate whether the information collected by nurse case managers at the time of an injury

**Alternative Indicators of Low Back Pain Recurrence**



*Preliminary work in an investigation of occupational low back pain recurrence demonstrates that a single workers compensation claim may include multiple recurring episodes of pain, functional impact, health care utilization, and disability.*

can be used to predict chronic, long-term disability cases.

With collaborators at the Harvard University School of Public Health, we conducted a statistical analysis of data from more than 1,100 cases of disabling low back injury. Each case included general injury information collected by a nurse case manager, as well as a checklist of potential risk factors for prolonged disability (e.g., inappropriate diagnosis, prolonged use of narcotics, age, gender, low educational attainment, and insufficient workplace accommodation). We hypothesized that the information collected by nurse case managers at the onset of an injury could be used to predict which cases would develop chronic disability beyond 180 days.

Initial study results indicated that, in general, disability duration was not strongly related to the risk factors presented in the checklist. However, a small number of cases were identified as being at a significantly higher risk for prolonged disability, based on specific combinations of risk factors including age, language barriers, and educational attainment. Data analysis also revealed that the time interval between the date of the occupational injury and referral to a nurse case manager had no significant modifying effect on any of the identified risk factors.

## Disability Prevention

Research suggests that employer responses to occupational injuries have a significant impact on the likelihood of prolonged disability. We are currently conducting field studies to identify the most effective methods to improve first aid services, initial employer responses, and work accommodations, in order to reduce disability and promote safe and sustained return to work.

### *Effects of Supervisor Training*

Work continued on our series of field studies to investigate the effects of supervisor training on disability outcomes. The goal of this research is to determine whether teaching supervisors how to respond when an employee is injured can reduce or prevent disability. Our researchers are currently developing and testing training programs at various participating companies.

We refined the supervisor training intervention based on the pilot study results, and conducted more than 50 interviews with employees and supervisors at two manufacturing firms. The training program, which was expanded from one to four hours, includes an overview of ergonomics principles and risk factors. It also

features modules on communicating with injured employees, understanding the disability process, developing accommodation plans, and locating resources to facilitate return to work. Supervisor/employee role-playing and a question-and-answer session complete the program.

Our researchers administered the training intervention to supervisors at an industrial food processing plant. We measured the effects of the intervention with pre- and post-intervention assessments of disability knowledge and attitudes. Preliminary results suggest that the training may improve a supervisor's ability to prevent lost time and facilitate return to work. Arrangements are underway to administer the training intervention and assessments at two additional companies in 2002.

**Our field study of factors that influence low back disability used interactive voice response technology to collect follow-up data from injured workers via telephone.**

# Publications

## *Journal of Occupational Rehabilitation*

Disability Management  
Training for Supervisors:  
A Pilot Intervention Program

## *Disability and Rehabilitation*

Early Prognosis for  
Low Back Disability:  
Intervention Strategies  
for Health Care Providers

## *Human and Ecological Risk Assessment*

Prognosis in Acute  
Occupational Low-Back  
Pain: Methodologic and  
Practical Considerations

### Work-Related Back Injury



Thank you for  
volunteering

ly risk assessment  
low back disability

es recruited and surveyed during initial  
ion visit, risk factors assessed,  
ards prompt follow-up calls to PRG  
to post-injury  
patients provide information regarding  
e of medical treatment  
e levels of pain and function  
a work status





## *Collaborations & Extramural Activities*

To realize a strategy of helping advance global safety and health, the Research Center maintains collaborative relationships with premier research organizations around the world, including the Harvard School of Public Health; China's Chongqing University and Fudan University; the University of Aberdeen in Scotland; and the Health and Safety Laboratory in the United Kingdom.

The Research Center also conducts various activities aimed at increasing awareness of occupational safety and health and enhancing worker safety. These endeavors include the Center's Visiting Scholar Program as well as special awards to recognize excellence in safety and health research. Each of these extramural activities contributes to our expanding portfolio of global safety and health research and enhances our existing research programs.

# Research Partners

## China Research Partnerships

In a year in which China gained membership in the World Trade Organization, the Research Center and its partners from China's occupational health and safety community continued to exchange ideas and information. This exchange is aimed at improving workplace safety in China.

In partnership with the Chinese State Economic and Trade Commission's newly formed State Administration for Work Safety Supervision (SAWSS), we hosted the Third Annual China SafeWork Forum in Shanghai. This year's Forum, *New Century, New Challenge: Create Better Safe Working Conditions*, brought more than 150 participants including health and safety experts, government officials, and representatives from enterprises in the US, China, and other Asian nations.

Charles Jeffress, Assistant Secretary of Labor for Occupational Safety and Health under the Clinton administration, delivered the US

keynote address, "US Safety Legislation." Shan Chunchang, Deputy Director-General, SAWSS, provided the Chinese keynote, "Enhancing Work Safety Supervision and Management, Adapting to the Socialist Market Economy." The research segment included presentations on the work of the Liberty Mutual SafeWork Centers at Fudan University (Shanghai), Chongqing University, and the Liberty Mutual Research Center for Safety and Health.

In addition to co-hosting the Forum, we welcomed delegations from both the State Economic and Trade Commission and the China Insurance Regulatory Commission of the People's Republic of China to the Research Center. Each delegation shared their insights regarding worker safety and health with the Research Center's scientific staff and members of Liberty Mutual's Loss Prevention Department. These visits provided a unique opportunity for participants to discuss occupational safety and injury research, as well as best practices in loss prevention.

### Liberty Mutual-Harvard Program in Occupational Safety and Health

In 2001 the Liberty Mutual-Harvard Program strengthened its emphasis on occupational safety and injury. Harvard and Liberty Mutual scientists laid the groundwork for a new doctoral program in Occupational Injury Epidemiology and Safety Science at the Harvard School of Public Health. The institutional collaboration successfully competed for funding of the new degree program from the US Centers for Disease Control and Prevention.

During the year, the Department of Environmental Health in the

School of Public Health launched a faculty search for an assistant professor of occupational injury epidemiology. Both the funding and the faculty search initiatives extensively leveraged the prior seven years of success with graduate and post-graduate research and training in occupational injury under the Liberty Mutual-Harvard Program.

The Liberty Mutual-Harvard Program also continued to make progress on several research projects including administrative data studies, field studies of injury risk factors, intervention studies, and laboratory studies of human capacities. See the inset box for a listing of Liberty Mutual-Harvard

Program projects which are described in more detail in other sections of this Report.

### Special Issue on the Measurement of Slipperiness

In a special October issue, the journal *Ergonomics* published the proceedings of our international, multidisciplinary symposium, *The Measurement of Slipperiness*. This meeting, the second in a series of Hopkinton Symposia on science and scientific methods, promoted development of a global perspective on methodological issues in slipperiness measurement. The symposium drew on a network of research professionals

Joint Liberty-Harvard Research Projects
Risk Factors for Acute Traumatic Hand Injuries in the Workplace, page 6
Slips, Trips, and Falls in Health Care Workers: A Case-Crossover Study, page 7
Work-Related Low Back Disorders and the Impact of Physician Practice Patterns on the Length of Disability, page 24
Risk Prediction and Prognosis of Work-Related Low Back Pain Based on Case Manager Information, page 29

*The Liberty Mutual-Harvard Program made progress on several research projects and continued to facilitate the exchange of ideas and technologies between the institutions. The above chart highlights research projects that are covered in detail on the indicated pages of this Report.*

# Publications

## ***Ergonomics*** **Special Issue**

The Measurement of  
Slipperiness – An  
International Symposium

Measurement of  
Slipperiness: Fundamental  
Concepts and Definitions

Occupational Slip, Trip,  
and Fall-Related Injuries:  
Can the Contribution of  
Slipperiness Be Isolated?

Biomechanics of Slips

Human-Centered  
Approaches in Slipperiness  
Measurement

The Role of  
Surface Roughness  
in the Measurement  
of Slipperiness

The Role of Friction  
in the Measurement of  
Slipperiness, Part I:  
Friction Mechanisms  
and Definition of  
Test Conditions

The Role of Friction  
in the Measurement of  
Slipperiness, Part II:  
Survey of Friction  
Measurement Devices

representing clinical, engineering, psychological, physiological, and epidemiological perspectives from around the world.

The special issue of *Ergonomics* (Vol. 44, No.13) contains eight collaborative, peer-reviewed papers. Topics included: fundamental concepts and definitions in slipperiness measurement; the contribution of slipping to the occupational slips and falls injury burden; slips and

falls biomechanics; human-centered methods of measuring slipperiness; surface roughness considerations; and friction-based measures including a comprehensive paper on slipmeters.

These results, along with additional discussion material on the state and future direction of slipperiness measurement from the conference, will become available as a Taylor and Francis monograph in 2002.

## Visiting Scholar

In its seventh year, the Visiting Scholar program continues to provide collaborative opportunities for senior researchers from around the world. Each year, the Center hosts a distinguished scholar to work with researchers on a new or ongoing initiative of mutual interest. The program requires a minimum of one joint publication resulting from the research project, and fosters a longer collaborative relationship between the Research Center and the scholar's home institution.

Dal Ho Son, PhD, of Taegu, Korea, was selected as the year 2001 Visiting Scholar. While at the Center, he helped initiate a slips and falls research project to examine accidents related to ladder use. The project aims to develop an experimental apparatus that will measure the force and motion of human subjects as they climb and descend a ladder. Following his tenure, Dr. Son continues to collaborate with the Center to complete this project. The published results will include recommendations for reducing the risk of ladder accidents.

Dr. Son is a professor in the Department of Industrial Engineering and Management Information Systems (MIS) at Keimyung University, Taegu, Korea. He also serves as a consulting advisor in the Korea Consulting Institute, Seoul, Korea, and as director of the planning department at Taegu-Techno Park. His prior positions at Keimyung University included head of the Department of Industrial Engineering and MIS; associate dean of the School of Engineering; and director of the Venture Center. He began his professional career in the private sector as a systems engineer for Gold Star Electronic Company in Seoul.

A graduate of Texas Tech University, Dr. Son received both his PhD and MS in Industrial Engineering. He earned a BS in Mechanical Engineering from Korea's Kyungpook National University. A member of the Institute of Industrial Engineers and the Ergonomics Society, Dr. Son has published 68 papers, with most focusing on human safety and human-computer interaction.



Dal Ho Son, PhD

## Awards and Honors

In an effort to promote excellence in occupational safety and health research, the Research Center partners with prominent health and safety organizations on high profile awards. Two awards, the Liberty Mutual Prize of the International Ergonomics Association (IEA) and the Best Paper Award of the *International Journal of Industrial Ergonomics*, were presented in 2001.

### Liberty Mutual Prize

The Liberty Mutual Prize was awarded to Professor Peter A. Hancock, DSc, PhD, University of Central Florida, and Selma N. de Ridder, a graduate student at the University of Minnesota. Established jointly by Liberty Mutual and the IEA, the Prize recognizes winners for outstanding original research in the field of ergonomics and occupational safety and health.

Hancock and deRidder received the Prize for their original research as presented in the paper, "Behavioral Accident Avoidance Science: Understanding and Assessing Response in Accident Incipient Conditions." The paper discusses an innovative strategy that enables researchers to investigate the behav-

ioral aspects of collision avoidance in a safe and effective manner.

### Best Paper Award

Researchers from the University of Dortmund, Germany, won the 2001 Best Paper Award for their paper, "Evaluation and Assessment of Lumbar Load During Total Shifts for Occupational Manual Materials Handling Jobs within the Dortmund Lumbar Load Study (DOLLY)." The winning paper, authored by Matthias Jäger, PhD, Claus Jordan, Alwin Luttmann, PhD, Wolfgang Laurig, PhD, and members of the DOLLY Group, describes a study in which researchers used video analysis and biomechanical modeling to examine the occupationally induced load on the lumbar spine during manual materials handling.

The Best Paper Award program was initiated by the Research Center and the *International Journal of Industrial Ergonomics* to recognize excellence in safety and health research. The Award acknowledges the most outstanding paper published in the *International Journal of Industrial Ergonomics* during the previous year.



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# Presentations

## **Wen-Ruey Chang, PhD**

Annual Meeting of the American Academy of Forensic Sciences, "Experimental Approaches to the Prevention of Occupational Injuries Caused by Slips, Trips, and Falls Accidents," Seattle, WA, February 19-24

Society of Tribologists and Lubrication Engineering, "Tribology of Slips and Falls," Dayton, OH, December 5

## **Yueng-Hsiang Huang, PhD**

Society for Industrial and Organizational Psychology, "The Relationship Between Work Conditions and Work-to-Family Conflict: A Longitudinal Study," San Diego, CA, April 27-29

Gerontology Society of America, "Supporting Employees in the Sandwiched Generation: A Sourcebook for Employers," Chicago, IL, November 15-18

## **Theodore K. Courtney, MS, CSP**

Applied Ergonomics Conference, "Ergonomics Opportunities in the Insurance and Research Sectors," Orlando, FL, March 12-15

China SafeWork Forum, "Petrochemical Industry Safety – The Other Side of the Mountain," Shanghai, People's Republic of China, April 24-25

Harvard ERC Occupational Health Seminar, Harvard University, "Disabling Occupational Morbidity in the US – Making Sense of the BLS Data," Boston, MA, November 19

## **Krystyna Gielo-Perczak, PhD**

25th Annual Meeting of the American Society of Biomechanics, "Effects of Arch Support on Changes in Arch Height and Center of Pressure Under Different Foot Positions While Loading," San Diego, CA, August 8 -11

## **Tom B. Leamon, PhD**

Association of Workers Compensation Board of Canada, "From Research to Reality – Effective Knowledge Transfer: Getting the Ideas and Information to Those Who Need It," Toronto, ON, Canada, November 19-20

Injury Control Center Grand Rounds, "From Research to Reality – A Model," University of Alabama, Birmingham, AL, October 17

18th Workers Compensation Conference, "Sources of Loss in the Workers Compensation System," Chapel Hill, NC, June 14

Applications of Human Performance in Health and Disability, "People, Dead Camels and Coffee Tables," Cairo, Egypt, March 26-29

China SafeWork Forum, "People Mining Coal: Improvements to Safety and Production through Machine Design," Shanghai, People's Republic of China, April 24-25

## **David A. Lombardi, PhD**

Consortium for Injury and Disability Research, "A Reliability Study of Transient Risk Factors Nested in a Case-Crossover Study," Worcester, MA, March 27

## **Simon Matz, MS**

2001 Computer-Aided Ergonomics and Safety (CAES) Conference, "Walking Safety and Contact Time-Related Variation in Shoe/Floor Traction," Maui, HI, July 29-August 1

## **Raymond W. McGorry, MS, PT**

2001 Tri-State Physical Therapy Conference and Exposition, "The Reduction of Chronic, Non-Specific Low Back Pain by Avoidance of Trunk Flexion Upon Rising," Sturbridge, MA, October 20

## **Glenn S. Pransky, MD, MOccH**

Grand Rounds at Dartmouth College, Hitchcock Medical Center, "Outcomes Research in Low Back Pain at the Liberty Mutual Center for Disability Research," Hanover, NH, January 10

Sargent College/Interdisciplinary Research Seminar, "Older Workers, Work Injuries and Improved Outcomes: Results of Recent Investigations and Implications for Improvement," Boston, MA, January 26

Grand Rounds at Duke University School of Medicine, "Return to Work Research – State of the Art," Durham, NC, March 15-19

Innovations in Rehabilitation Medicine and Disability Medicine, "Identifying Barriers to Optimal Disability Outcomes: From Research to Reality," Vancouver, BC, Canada, April 4-6

Annual Meeting of the Robert Wood Johnson Foundation Workers Compensation Health Initiative, "Disability and Health Services Research Opportunities: Priorities for a New Millennium," Newport, RI, September 6-7

Outcomes Research Program of the 126th Neurological Association "Innovative Examination of Migraine in the Workplace: Methodology of the POEM Study," Chicago, IL, September 30-October 3

Eastern Maine Medical Center, "Protecting the Young Worker: Challenges for the Health Care Professional," Bangor, ME, October 1

Human Factors and Ergonomics Society 45<sup>th</sup> Annual Meeting, "Measuring Accommodations in the Workplace – Are Practical, Valid Methods Available?" Minneapolis, MN, October 8-12

Association for Public Policy Analysis and Management's 23<sup>rd</sup> Annual Research Conference, "Older Workers and Work-Related Injuries: Challenges in Integrating Workers Compensation and Group Health Medical Care," Washington, DC, November 1-3

Disability Management Employer Coalition: Topics in Disability Prevention, "Disability Management Training for Supervisors: A Pilot Intervention Program," Burlington, MA, November 7th

## **Michelle M. Robertson, PhD, CPE**

2001 International Telecommunications Safety Conference, "Biomechanical and Ergonomic Analysis of Lid Lifting Operations: Preliminary Results," Providence, RI, September 11

## **Matthias Roetting, PhD**

Eleventh European Conference on Eye Movements, "Systematics of Eye and Gaze Movement Parameters for Ergonomic Research and Application," Turku, Finland, August 22-25

## **William S. Shaw, PhD, PE**

Meeting of the Disability Management Employers Coalition, Boston Chapter, "The Role of Occupational Health Psychology in Return to Work Initiatives," Boston, MA, January 24

Annual Meeting of the Society of Behavioral Medicine, "Return to Limited Duty After a Work-Related Upper Extremity Disorder: Role of Perceived Functional Limitations and Workplace Ergonomic Exposure," Seattle, WA, March 22-25

Semi-Annual Meeting of the Workers Compensation Research Group, "What Factors Contribute to Low Back Disability After an Acute Onset of Occupational Low Back Pain?" Chicago, IL, July 14-15

Annual Meeting of the Robert Wood Johnson Foundation Workers Compensation Health Initiative, "An Evidence-Based Approach to Integrated Case Management for Work-Related Upper Extremity Disorders," Newport, RI, September 6-7

National Workers Compensation and Disability Conference and Exhibit, "Preventing Disability After Musculoskeletal Injuries," Chicago, IL, November 13

Meeting of the American Association of Occupational Health Nurses, New Hampshire Chapter, "Integrating Workplace Accommodation and Problem-Solving to Manage Work-Related Disabilities," Concord, NH, November 28

### **Gary S. Sorock, PhD**

National Safety Council Congress, "Glove Use and Hand Injury Prevention," Atlanta, GA, September 26

### **Radoslaw Wasiak, MA, MS**

International Conference on Health Policy Research, "Methodological Chal-

lenges in Studying Episodes of Care for Work-Related Low Back Pain," Boston, MA, December 7-9

### **Barbara S. Webster, RPT, PA-C**

Workers Compensation Research Group, "Costs of Work-Related Tetraplegic Spinal Cord Injuries," Cambridge, MA, March 10

American Academy of Physical Medicine and Rehabilitation, "Direct Medical Workers Compensation Costs for Tetraplegic Spinal Cord Injuries," New Orleans, LA, September 13-16

# Professional Activities

Research Center personnel participate in a variety of professional organizations, societies, and activities related to their respective areas of expertise. These memberships provide opportunities for researchers to interact with their peers, gain valuable scientific input, and recommend change in the standards and practices applicable to their fields. In addition, many of our researchers serve on review committees and editorial boards for leading health and safety scientific journals. Listed here are the organizations to which our researchers belong, the committees on which they have served, and the journals for which they have reviewed in 2001.

### ***Organizations and Societies***

American Academy of Physician Assistants

American College of Epidemiology

American College of Sports Medicine

American Economic Association

American Industrial Hygiene Association

American Pain Society

American Physical Therapy Association

American Psychological Association

American Public Health Association

American Society for Testing and Materials

American Society of Biomechanics

American Society of Mechanical Engineers

American Society of Safety Engineers

American Society of Safety Engineers Foundation

American Statistical Association

Association for Comparative Economic Studies

Association for Electrical Engineering, Electronics and Information Technology

Association for the Advancement of Automotive Medicine

Australasian Epidemiological Association

Board of Certified Safety Professionals

Commonwealth of Massachusetts Board of Registration of Physician Assistants

Computer Science Society of Germany

Consortium for Injury and Disability Research

Ergonomics Society

German Ergonomics Society

Human Factors and Ergonomics Society

Institute of Electrical Engineers

Institute of Industrial Engineers

International Council on Alcohol, Drugs and Traffic Safety

# Professional Activities

International Epidemiological Association  
International Society of Biomechanics  
Massachusetts Association of Physician Assistants  
New England Society of Applied Psychology  
Public Health Association of New Zealand  
Society for Epidemiologic Research  
Society of Behavioral Medicine  
Society of Industrial and Organizational Psychology

## Activities

Institute for Work and Health  
- Adjunct Scientist  
International Collaborative Effort on Injury Statistics  
- Coordinator, Sentinel Injury Evaluation Project  
International Conference for Human Computer Interaction  
-Scientific Organizing Committee  
Mass Medical Society Physician Health Program and Advisory Committee  
-Board of Directors  
National Center for Health Statistics  
- Consultant  
National Study Center for Trauma and EMS, University of Maryland  
- Consultant  
New England College of Occupational and Environmental Medicine  
- Board of Directors

National Institute for Occupational Safety and Health  
- National Occupational Research Agenda Traumatic Injuries Team  
- Traumatic Injury Study Team  
Occupational and Environmental Health Center of Rhode Island  
- Advisory Board Member  
Transportation Research Board  
- Committee on Alcohol, Drugs and Traffic Safety  
Workers Compensation Research Group

## Journal Reviews

*Accident Analysis and Prevention*  
*American Industrial Hygiene Association Journal*  
*American Journal of Epidemiology*  
*American Journal of Industrial Medicine*  
*American Journal of Public Health*  
*Annals of Epidemiology*  
*Annual Review of Public Health*  
*Applied Ergonomics*  
*Assistive Technology*  
*Behaviour and Information Technology*  
*Computers and Industrial Engineering*  
*Epidemiologic Reviews*  
*Ergonomics*  
*Injury Prevention*  
*International Journal of Industrial Ergonomics*

*International Journal of Occupational Safety and Ergonomics*  
*Journal of the American Medical Association*  
*Journal of Computers and Industrial Engineering*  
*Journal of Occupational Rehabilitation*  
*Journal of Psychosomatic Research*  
*MMI-Interaktiv*  
*New England Journal of Medicine*  
*Public Health Reports*  
*Rehabilitation Psychology*  
*Safety Science*  
*Theoretical Issues in Ergonomics Science*

Each year, the Research Center welcomes visitors from industry, academia, and government to tour the facilities and learn about our research programs. In 2001, the Center hosted the following visitors from around the world:

3M Company – St. Paul, MN	Battleground Restaurant Group – Greensboro, NC	Dartmouth-Hitchcock Medical Center – Dartmouth, NH
A Watts Inc. – Winston-Salem, NC	Behavioral Implications Management – Ashland, MA	Delta Technology Inc. – Atlanta, GA
AT Williams Oil Company – Winston-Salem, NC	Bob's Stores Inc. – Meriden, CT	Department of Foreign Affairs – Beijing, People's Republic of China
AC Corporation – Greensboro, NC	Brinker International – Dallas, TX	Department of Labor Protection – Beijing, People's Republic of China
ADP, Inc. – Roseland, NJ	Brookhaven National Lab – Upton, NY	Department of Policy and Legislation – Beijing, People's Republic of China
Aetna, Inc. – Hartford, CT	Campbell County Memorial Hospital – Gillette, WY	Department Three of Work Safety Supervision – Beijing, People's Republic of China
AFL-CIO – Washington, DC	Capitol Health Region – Victoria, BC, Canada	Eastman Kodak Company – Rochester, NY
AHA Financial Solutions Inc. – Chicago, IL	Catholic Health East – Springfield, MA	Environmental Justice Committee – Berkeley, CA
American Bakers Association – Washington, DC	Center to Protect Workers' Rights – Washington, DC	Finnish Institute of Occupational Health – Helsinki, Finland
American College of Occupational and Environmental Clinics – Milwaukee, WI	Central State Hospital – Petersburg, VA	FleetBoston Financial Corporation – Providence, RI
American Federation of State County and Municipal Employees – Washington, DC	Chemical Manufacturers Association – Arlington, VA	General Office – Beijing, People's Republic of China
American Greetings Corporation – Cleveland, OH	China Coal Information Institute – Beijing, People's Republic of China	Glacier Park Inc. – East Glacier Park, MT
American Psychological Association – Washington, DC	China Insurance Regulatory Commission – Beijing, People's Republic of China	Global Occupational Health Services - IBM – Armonk, NY
American Society of Safety Engineers Foundation – Des Plaines, IL	Coca-Cola Bottling Company of Northern New England Inc. – Bedford, NH	Goodwill Industries of Northern New England – Portland, ME
Association of Occupational Environmental Clinics – Washington, DC	Commonwealth of Virginia – Petersburg, VA	Hanford Community Medical Center – Hanford, CA
	COSTS – Altoona, IA	
	Darden Restaurants – Orlando, FL	

# Visitors

Herman Miller Inc. – Zeeland, MI	National Institute for Occupational Safety and Health – Washington, DC	State Administration of Work Safety – Beijing, People’s Republic of China
IBM – White Plains, NY	National Institute of Environmental Health Sciences – Research Triangle Park, NC	State Plans, Department of Labor and Industries – Olympia, WA
Ingles Markets – Asheville, NC	National Safety Council – Washington, DC	Steelcase Inc. – Grand Rapids, MI
JC Steele and Sons Inc. – Statesville, NC	National Safety Training Center of Coal Mines – Beijing, People’s Republic of China	STERIS Corporation – Montor, OH
Kadlec Medical Center – Richland, WA	Navistar International Transportation Corporation – Chicago, IL	The St. Paul Companies – Ocean Springs, MS
KeySpan Corporation – Mineola, NY – Hicksville, NY	Omni Services Inc. – Culpeper, VA	The University of Michigan – Ann Arbor, MI
Klaussner Furniture Industries – Asheboro, NC	Organization Resources Counselors Inc. – Washington, DC	The University of North Carolina at Chapel Hill – Chapel Hill, NC
Krispy Kreme – Winston-Salem, NC	PETRO – Stamford, CT	UCLA School of Public Health – Los Angeles, CA
Lawrence Industries – Burlington, NC	PPG Industries – Lexington, NC	United Auto Workers – Detroit, MI
Leonard Aluminum Building – Mt. Airy, NC	Prevent – Stockholm, Sweden	University of California at Berkeley – Berkeley, CA
Massachusetts General Hospital – Boston, MA	Raytheon Aerospace Company – Madison, MS	University of Michigan – Ann Arbor, MI
McKinsey and Company Inc. – Boston, MA	Raytheon Company – Sudbury, MA	USAA – San Antonio, TX
MedStar Health – Columbia, MD	Risk Management Associates – Boston, MA	UST, Inc. – Greenwich, CT
Microsoft – Redmond, WA	SBC Communications – Tustin, CA	VWR International – West Chester, PA
Midcentral Health – Palmerston North, New Zealand	Seacoast Coca-Cola Bottling Company – Seabrook, NH	Waste Management – Hampton, NH
MidMichigan – Midland, MI – Clare, MI	South Dakota School of Mines and Technology – Rapid City, SD	Waters Corporation – Milford, MA
Motor Accidents Authority of NSW – Sydney, NSW, Australia		Xerium Inc. – Westborough, MA

## How to Contact Us

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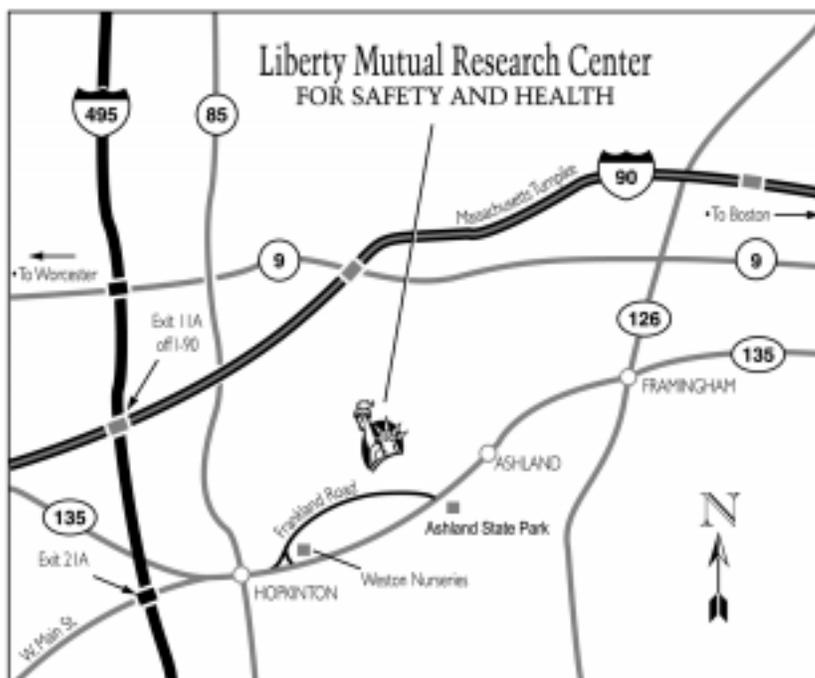
### From Boston via Massachusetts Turnpike (Interstate 90)

Take 90 west to Exit 11A (495 South). Take 495 south to Exit 21A (W. Main St. Hopkinton). Go east on W. Main St., which becomes Rte. 135. Proceed on 135 through the lights at Hopkinton Center (Colella's grocery store). About a mile and a half past Hopkinton Center, bear left onto Frankland Road (the turn is at the crest of a small hill; a small sign indicates

where you enter for Frankland Road). On Frankland Road, follow the signs to the Research Center. The entrance will be on your left after a long, stone fence.

### From Framingham via Route 135

Take Rte. 135 west out of Framingham. Follow through Ashland, past Dairy Queen, Honeydew Donuts, and then a Mobil station. Shortly after the Mobil you will see Ashland State Park on your left. On the right side of the street is a small, white sign pointing to the Research Center. Take that right onto Frankland Road. After the intersection (stop sign) at Cross Street, the Research Center will be the first right.



### Research

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Patrick G. Dempsey, PhD, CPE  
Alfred J. Filiaggi, CSP  
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Raoul A. Grönqvist, PhD  
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The Liberty Mutual Research Center for Safety and Health in Hopkinton, Massachusetts, is a company-owned and operated occupational health and safety research facility. The Research Center is recognized throughout the world for its continuing contributions to the prevention of workplace injury and illness and for the control of work-related disability.

The Center houses two entities, the Center for Safety Research (CSR) and the Center for Disability Research (CDR). The CSR investigates the causes of accidents and injuries, human capacities for various job tasks, and ways to enhance on-the-job safety. The CDR studies the causes, consequences, and prevention of disability in workers, and aims to achieve safe and sustained return to work for injured or ill workers.

Through broad-based research programs and in close collaboration with researchers and practitioners around the world, the Research Center is dedicated to a common purpose, embodied in the Liberty Mutual Creed, *to help people live safer, more secure lives.*

