Memorandum

Date: February 11, 2003

From: Lee M. Sanderson, Ph.D., Program Official
Office of Extramural Programs, NIOSH, E-74

Subject: Final Report Submitted for Entry into NTIS for Grant 5 R01 OH003809-02.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment
cc: Sherri Diana, EID, P03/C13

List of Publications

Lipscomb HJ, Dement JM, Li L, Nolan J, Pattern D: Nail Gun Injuries in Residential Carpentry: Lessons from Active Surveillance. Injury Prevention, in press, 2002

Dement JM, Lipscomb H, Li L, Epling C, Desai T: Surveillance of Nail Gun Injuries Among Construction Workers. Applied Occupational and Environmental Hygiene, in press, 2002

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D: Descriptive Epidemiology of Work-Related Injuries in Residential and Drywall Carpentry from Active Injury Surveillance. Applied Occupational and Environmental Hygiene, in press, 2002

Title:	Etiology of Injury in Drywall and Residential Carpentry
Investigator:	Hester J. Lipscomb
Affiliation:	Duke University
City & State:	Durham, NC
Telephone:	(919) 286-3232
Award Number:	5 R01 OH003809-02
Start & End Date:	9/30/1999–9/29/2002
Total Project Cost:	$755,348
Program Area:	Traumatic Injuries
Key Words:	

Final Report Abstract:
Information on the etiology of work-related injuries among construction workers has been limited by practical problems which make the study of their health and safety hazards difficult; these are especially salient when considering those who do residential and drywall work. These are very mobile workforces with individuals frequently changing job sites and even employers. In residential construction, particularly, the duration of work at any given site is shorter in nature than in commercial construction and the nature of the work changes from day to day. Job sites are typically smaller with fewer workers at any given site.

We report on an active injury surveillance project designed to test the utility and feasibility of active injury investigations in identifying causes of work-related injury among a large cohort of residential and drywall carpenters. The program was designed to document the magnitude of injuries among these carpenters, to describe in detail the nature of their injuries and the circumstances surrounding these events. In addition, to explore risk factors for prolonged loss of time from work after a back injury among these high risk construction workers, comparisons were made between injuries, and workers experiencing these injuries, which resulted in rapid return to work and those which resulted in more prolonged work absence (> 1 month).

A group of 20 contractors were recruited to participate in the surveillance program, agreeing to report OSHA recordable injuries to the project office as they occurred on their work sites. Experienced journeymen carpenters with safety training and training in questionnaire administration and informed consent interviewed the injured carpenters about the circumstances surrounding their injuries. These carpenter investigators also conducted site assessments, using a standard format, where falls occurred. The union provided enumeration of the carpenters working for these contractors, their union status (apprentice vs journeyman) and hours worked by person by contractor by month, providing person-hours of work as a measure of time at risk; this allowed the estimation of injury rates. These data were supplemented with a series of focus groups designed to collect information about exposures of apprentices, training and mentoring in skills and safety training, perception of risk, and job stressors. In addition, a small group of self-insured contractors provided their workers' compensation data for the years 1995-2000 for analyses. The latter provided some information on costs associated with work-related injuries among residential carpenters.

After a period of pre-testing, active surveillance data were collected over 37 months beginning in September of 1999. The dynamic cohort consisted of5,137 carpenters who worked for one of20 participating contractors during this time period, representing a total of9,346,603 carpenter hours. Between September 1, 1999 and September 30, 2002 a total of 783 injuries were reported. Of these, 586 injured carpenters participated in injury investigation interviews (74.8%).

Injuries were most commonly caused by the carpenter being struck by or against something, manual materials handling tasks or some other type of overexertion, falls from elevations, and falls from the same level. Injuries involved the upper extremities over 40% of the time followed by the lower extremity, axial skeleton/trunk, and the head and face including the eyes. The injuries that resulted from being struck by or against something were largely cuts, puncture wounds, scratches/abrasions (including eye injuries), and contusions (87%). Nearly 90% of the overexertion injuries resulted in sprains and strains. Falls from height and same level falls most often resulted in sprains/strains or contusions, but 26% and 17% of these falls, respectively, resulted in fractures.

The most common struck by injuries involved pneumatic nail guns. Materials being handled at the time of overexertion injuries were most commonly associated with handling of building materials. The carpenter was handling an object weighing greater than 100 pounds 48% of the time and 200 or more pounds 28% of the time. Carpenters fell from a wide variety of surfaces most commonly ladders, scaffolds and unsecured work surfaces. While some falls were related to challenges in residential building with lack of appropriate anchor points, the vast majority could have been prevented through use of recognized fall prevention and protection strategies such as use of guardrails, covering openings, and appropriate ladder and scaffold use. Same level falls were often related to weather, housekeeping or terrain issues, such as tripping over debris, difficult work terrain (rocky, muddy, uneven); the slope of lot, lack of backfill around the foundation, difficult access, and/or egress from the building.

The estimated overall injury rate was 16.8 per '200,000 hours worked (783/9.3 million hours). There were 290 injuries that resulted in lost time from work beyond the day of injury (50% of those interviewed; data item missing for 37), representing a lost-time injury rate of 6.3 per 200,000 hours worked based only on individuals who were interviewed. If those who participated were representative of the pool of injuries, this rate would be as high as 8.4 per 200,000 hours. The injury rate among apprentices was 16.3 per 200,000 hours worked (95% CI 14.3 to 18.4) compared to 10.8 per 200,000 hours worked (95% CI 9.7 to 12.1) among journeymen (RR=1.5). Rates were significantly higher overall among apprentices and for injuries that resulted from being struck by or against something (RR=1.9). Nail gun injuries, in particular, occurred at rates 3.1 times higher among apprentices.

A significant proportion of back injuries, nearly 30%, were the result of acute trauma from falls or being struck. Among the manual materials handling back injuries there was

some indication that the injuries resulting in prolonged loss of time from work were associated with inciting events that created greater acute spinal loads.

Data from the self-insured homebuilders group for a six year period were consistent with the active surveillance reports. These compensation data demonstrated falls from elevations to be the most costly injuries; they were responsible for the greatest overall costs (even though they ranked third in frequency) and the greatest cost per claim. Fall rates declined 46% between 1997 and 2000, and total costs for falls fell to a rankof4th in 1998, 2nd in 1999, and again 4th in 2000. Mean costs per fall were markedly down in 2000 averaging about $7500 per fall compared to a range in previous years of $30,000 per fall (1995) to $12,000 per fall (1998).

Overexertion, largely involving manual materials handling, injuries were up 20% in 2000 compared to 1995. Also consistent with the active surveillance findings at least 26% of costs for back injuries that were not the result of manual materials handling tasks or exertion. These injuries were the result of falls, being struck by walls, or slipping. The greatest costs for back injuries were from injuries resulting from lifting framed walls or setting steel beams.

Injured carpenters insights into what contributed to their injuries varied by type of injury, but time pressures and speed of work were the most common factors carpenters acknowledged. Forty- seven percent (47%) of workers who experienced a same level fall felt time pressures contributed to the circumstances leading to injury, and 20% attributed housekeeping issues. Overexertion injuries were most often attributed to the task being too heavy (34%) or the carpenter needing help (25%).

Surveillance, such as this, yields information on factors that contribute to injuries among high risk construction workers who are difficult to study for practical reasons. The active surveillance is more time consuming than passive surveillance activities, but the information is more useful for understanding the circumstances surrounding injuries and in formulation of concrete preventive recommendations. There are challenges in identifying methods to capture injuries completely and in a timely manner to allow rapid investigation.

Publications

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D: Descriptive Epidemiology of Work-Related Injuries in Residential and Drywall Carpentry from Active Injury Surveillance. Applied Occupational and Environmental Hygiene, in press, 2002

Dement JM, Lipscomb H, Li L, Epling C, Desai T: Surveillance of Nail Gun Injuries Among Construction Workers. Applied Occupational and Environmental Hygiene, in press, 2002

Lipscomb HJ, Dement JM, Li L, Nolan J, Pattern D: Nail Gun Injuries in Residential Carpentry: Lessons from Active Surveillance. Injury Prevention, in press, 2002

FINAL PROJECT REPORT

RO1 OH 03809

National Institute for Occupational Safety and Health

Centers for Disease Control and Prevention

Project title: Etiology of Injury in Residential and Drywall Carpentry

Principal Investigator: Hester J. Lipscomb, Ph.D.*
Associate Professor

Co-investigators: John M. Dement, Ph.D., CIH*
Associate Professor

James Nolan^
Journeyman, Local 2119

Dennis Patterson^
Journeyman, Local 1310

Wilfred Cameron, CIH+
Director of Training

Gary Mirka, Ph.D.
Associate Professor

Affiliations: Division of Occupational and Environmental Medicine*
Duke University Medical Center
Box 3834
Durham, N.C. 27710

Carpenters District Council of Greater St. Louis^
St. Louis, Missouri

Center to Protect Workers Rights+
Silver Spring, Maryland

Industrial Engineering Department
North Carolina State University
Raleigh, N.C.

December 2002

TABLE OF CONTENTS

List of Abbreviations

3DSSPP – Three-Dimensional Static Strength Prediction Program

ANSI – American National Standards Institute

BLS – Bureau of Labor Statistics

CABS – Continuous Assessment of Back Stress

CDC – Carpenters District Council
– Centers for Disease Control and Prevention

FACE – Fatalities Assessment Control and Evaluation

LMM – Lumbar Motion Monitor

MMH – Manual Materials Handling

NIOSH – The National Institute for Occupational Safety and Health

OCS – Observational Coding System

OSHA - Occupational Safety and Health Adminstration

PHRGM – Probability of High Risk Group Membership

PPE - Personal Protective Equipment

RWL – Recommended Weight Limit

SIC – Standard Industrial Codes

SLIPP – St. Louis Injury Prevention Project

Glossary of Construction Terms

Term	Definition
Backfill	Fill around the foundation
Baker's scaffold	Platform scaffold
Band iron	Bands wrapped around materials when delivered to construction sites
Concrete forms	Forms used to hold concrete until it dries
GFCI	Ground fault circuit interrupter
I-beam	Steel beam; on end it looks like an I
Joist	Supports for sub-flooring; typically 2x10's or newer TGI's which are 2 2x2'swith plywood in between
Joist hangers	Metal pockets for joists to fit in
Ladder jacks	Scaffolding rigged on a pair of ladders with use of jacks that can be adjusted; large (pic) board is used as a work surface between the jacks.
OSB board	Oriented strand board; plywood
Overdig	Usually 3 feet wider than foundation wall; room needed to set concrete forms
Paralam (Microlam)	Beam made of long, thin strands of wood that are structurally bonded together in a patented microwave process, to make large cross section beams and columns
Perry scaffold	Platform scaffold
Pic board	Large, heavy board used as a work surface on ladder jacks
Pocket square	Small square carpenter can keep in pocket
Sub-floor	Plywood flooring which is covered by wood, carpet, or other flooring
Toe boards	2x4's nailed to roof to prevent sliding
Top plate	Top of framed wall

Term	Definition
Truss	A component part of roof, usually put on 2' centers all the way across the house.
Whaler board	These are usually 2"x4" s on the outside of forms to straighten the concrete forms. They are held to the forms with small ties called whaler ties.
Apprentice	Carpenter still involved in formal training; typically lasts 4 years. Should have increasing responsibility on job sites as progresses in program.
Journeyman	Carpenter who has finished formal training program or was "grandfathered in" based on non-union experience.
Foreman	Typically journeyman carpenter; has responsibility for a number of other carpenters, a job site or home etc.
Steward	Individual who is a carpenter serving as an advocate for other union carpenters regarding benefits, safety, work conditions, etc.
Supervisor	Carpenter who is head of a number of foremen; usually head of the building of a sub-division for instance.

List of Figures

List of Tables

ABSTRACT

Information on the etiology of work-related injuries among construction workers has been limited by practical problems which make the study of their health and safety hazards difficult; these are especially salient when considering those who do residential and drywall work. These are very mobile workforces with individuals frequently changing job sites and even employers. In residential construction, particularly, the duration of work at any given site is shorter in nature than in commercial construction and the nature of the work changes from day to day. Job sites are typically smaller with fewer workers at any given site.

We report on an active injury surveillance project designed to test the utility and feasibility of active injury investigations in identifying causes of work-related injury among a large cohort of residential and drywall carpenters. The program was designed to document the magnitude of injuries among these carpenters, to describe in detail the nature of their injuries and the circumstances surrounding these events. In addition, to explore risk factors for prolonged loss of time from work after a back injury among these high risk construction workers, comparisons were made between injuries, and workers experiencing these injuries, which resulted in rapid return to work and those which resulted in more prolonged work absence (> 1 month).

A group of 20 contractors were recruited to participate in the surveillance program, agreeing to report OSHA recordable injuries to the project office as they occurred on their work sites. Experienced journeymen carpenters with safety training and training in questionnaire administration and informed consent interviewed the injured carpenters about the circumstances surrounding their injuries. These carpenter investigators also conducted site assessments, using a standard format, where falls occurred. The union provided enumeration of the carpenters working for these contractors, their union status (apprentice vs journeyman) and hours worked by person by contractor by month, providing person-hours of work as a measure of time at risk; this allowed the estimation of injury rates. These data were supplemented with a series of focus groups designed to collect information about exposures of apprentices, training and mentoring in skills and safety training, perception of risk, and job stressors. In addition, a small group of self-insured contractors provided their workers' compensation data for the years 1995-2000 for analyses. The latter provided some information on costs associated with work-related injuries among residential carpenters.

After a period of pre-testing, active surveillance data were collected over 37 months beginning in September of 1999. The dynamic cohort consisted of 5,137 carpenters who worked for one of 20 participating contractors during this time period, representing a total of 9,346,603 carpenter hours. Between September 1, 1999 and September 30, 2002 a total of 783 injuries were reported. Of these, 586 injured carpenters participated in injury investigation interviews (74.8%).

Injuries were most commonly caused by the carpenter being struck by or against something, manual materials handling tasks or some other type of overexertion, falls from elevations, and falls from the same level. Injuries involved the upper extremities over 40% of the time followed by the lower extremity, axial skeleton/trunk, and the head and face including the eyes. The injuries that resulted from being struck by or against something were largely cuts, puncture wounds, scratches/abrasions

(including eye injuries), and contusions (87%). Nearly 90% of the overexertion injuries resulted in sprains and strains. Falls from height and same level falls most often resulted in sprains/strains or contusions, but 26% and 17% of these falls, respectively, resulted in fractures.

The most common struck by injuries involved pneumatic nail guns. Materials being handled at the time of overexertion injuries were most commonly associated with handling of building materials. The carpenter was handling an object weighing greater than 100 pounds 48% of the time and 200 or more pounds 28% of the time. Carpenters fell from a wide variety of surfaces most commonly ladders, scaffolds and unsecured work surfaces. While some falls were related to challenges in residential building with lack of appropriate anchor points, the vast majority could have been prevented through use of recognized fall prevention and protection strategies such as use of guardrails, covering openings, and appropriate ladder and scaffold use. Same level falls were often related to weather, housekeeping or terrain issues, such as tripping over debris, difficult work terrain (rocky, muddy, uneven); the slope of lot, lack of backfill around the foundation, difficult access, and/or egress from the building.

The estimated overall injury rate was 16.8 per 200,000 hours worked (783/9.3 million hours). There were 290 injuries that resulted in lost time from work beyond the day of injury (50% of those interviewed; data item missing for 37), representing a lost-time injury rate of 6.3 per 200,000 hours worked based only on individuals who were interviewed. If those who participated were representative of the pool of injuries, this rate would be as high as 8.4 per 200,000 hours. The injury rate among apprentices was 16.3 per 200,000 hours worked (95% CI 14.3 to 18.4) compared to 10.8 per 200,000 hours worked (95% CI 9.7 to 12.1) among journeymen (RR=1.5). Rates were significantly higher overall among apprentices and for injuries that resulted from being struck by or against something (RR=1.9). Nail gun injuries, in particular, occurred at rates 3.1 times higher among apprentices.

A significant proportion of back injuries, nearly 30%, were the result of acute trauma from falls or being struck. Among the manual materials handling back injuries there was some indication that the injuries resulting in prolonged loss of time from work were associated with inciting events that created greater acute spinal loads.

Data from the self-insured homebuilders group for a six year period were consistent with the active surveillance reports. These compensation data demonstrated falls from elevations to be the most costly injuries; they were responsible for the greatest overall costs (even though they ranked third in frequency) and the greatest cost per claim. Fall rates declined 46% between 1997 and 2000, and total costs for falls fell to a rank of 4th in 1998, 2nd in 1999, and again 4th in 2000. Mean costs per fall were markedly down in 2000 averaging about $7500 per fall compared to a range in previous years of $30,000 per fall (1995) to $12,000 per fall (1998).

Overexertion, largely involving manual materials handling, injuries were up 20% in 2000 compared to 1995. Also consistent with the active surveillance findings at least 26% of costs for back injuries that were not the result of manual materials handling tasks or exertion. These injuries were the

result of falls, being struck by walls, or slipping. The greatest costs for back injuries were from injuries resulting from lifting framed walls or setting steel beams.

Injured carpenters insights into what contributed to their injuries varied by type of injury, but time pressures and speed of work were the most common factors carpenters acknowledged. Forty-seven percent (47%) of workers who experienced a same level fall felt time pressures contributed to the circumstances leading to injury, and *20%* attributed housekeeping issues. Overexertion injuries were most often attributed to the task being too heavy (34%) or the carpenter needing help (25%).

Surveillance, such as this, yields information on factors that contribute to injuries among high risk construction workers who are difficult to study for practical reasons. The active surveillance is more time consuming than passive surveillance activities, but the information is more useful for understanding the circumstances surrounding injuries and in formulation of concrete preventive recommendations. There are challenges in identifying methods to capture injuries completely and in a timely manner to allow rapid investigation.

SIGNIFICANT FINDINGS

Overall

- Injuries were most commonly caused by the carpenter being struck by or against something, manual materials handling tasks or some other type of overexertion, falls from elevations, and falls from the same level.
- Injuries involved the upper extremities over 40% of the time followed by the lower extremity, axial skeleton/trunk, and the head and face including the eyes.
- The injuries that resulted from being struck by or against something were largely cuts, puncture wounds, scratches/abrasions (including eye injuries), and contusions (87%). Nearly 90% of the overexertion injuries resulted in sprains and strains. Falls from height and same level falls most often resulted in sprains/strains or contusions, but 26% and 17% of these falls, respectively, resulted in fractures.
- Materials being handled at the time of overexertion injuries were most commonly associated with handling of building materials. The carpenter was handling an object weighing greater than 100 pounds 48% of the time and 200 or more pounds 28% of the time.
- Carpenters fell from a wide variety of surfaces most commonly ladders, scaffolds and unsecured work surfaces. Falls were often caused by failure to consistently follow recognized methods to prevent falls.
- Same level falls were often related to weather, housekeeping or terrain issues, such as tripping over debris, difficult work terrain (rocky, muddy, uneven); the slope of lot, lack of backfill around the foundation, difficult access, and/or egress from the building.
- The estimated overall injury rate was 16.8 per 200,000 hours worked (783/9.3 million hours). There were 290 injuries that resulted in lost time from work beyond the day of injury, representing a lost-time injury rate of 6.3 per 200,000 hours worked based only on individuals who were interviewed. If those who participated were representative of the pool of injuries, this rate would be as high as 8.4 per 200,000 hours.
- The injury rate among apprentices was 16.3 per 200,000 hours worked (95% CI 14.3 to 18.4) compared to 10.8 per 200,000 hours worked (95% CI 9.7 to 12.1) among journeymen (RR=1.5). Rates were significantly higher overall among apprentices and for injuries that resulted from being struck by or against something (RR=1.9). Nail gun injuries, in particular occurred at rates 3.1 times higher among apprentices.
- Overexertion injuries overall occurred at similar rates for apprentices and journeymen. However, apprentices had back injury rates that were 50% higher than journeymen and knee and shoulder injuries that were lower.
- Injured carpenters insights into what contributed to their injuries varied by type of injury, but time pressures and speed of work were the most common factors carpenters acknowledged. Forty-seven percent (47%) of workers who experienced a same level fall felt time pressures contributed to the circumstances leading to injury, and 20% attributed housekeeping issues. Overexertion injuries were most often attributed to the task being too heavy (34%) or the carpenter needing help (25%).

Pneumatic nail guns

- Nail guns were responsible for an estimated 14% of injuries among residential carpenters.
- Nail guns were the single greatest cause of struck by injuries among residential carpenters, responsible for >20% of these injuries.
- Injury rates were over three times higher among apprentice carpenters than journeymen, likely due to greater exposure to these tools and inexperience.
- Over 65% of injuries associated with contact trip guns could likely be prevented by sequential triggers.
- Prevention should involve training, engineering and policy changes involving carpenters and contractors, and these efforts should be evaluated and informed by ongoing injury surveillance.

Falls

- Falls accounted for 20% of injuries reported and investigated among these carpenters and falls were twice as common from heights as from the same level.
- There was only one fall in which the carpenter was using personal protective equipment and this fall was arrested at 12 feet and resulted in minor injury.
- Falls from the same level were most often related to weather, carrying objects - sometimes with view obstructed, housekeeping, terrain of the building lot, and speed of work.
- Falls from height occurred from a wide variety of work surfaces and often involved ladders, work on unsecured surfaces, scaffolding, and unprotected openings as well as speed and weather conditions.
- Sites on which falls from height had occurred were less likely to have workers using hard hats and eye protection and more likely to have poor housekeeping and materials storage and unacceptable scaffolding - providing some indication that the overall safety climate may be less good on these sites.
- Use of proper ladders of appropriate size for the job, setting them appropriately - staking and moving them frequently as required by the work are all important.
- Ladder jacks used for scaffolding are difficult to manage – creating fall hazards and manual materials handling risk. Carpenters recommend the use of pump jacks which are lighter to set up and easier to adjust to increasing height.
- Apprentices had rates of falls from elevations that were 50% higher than journeyman, but falls from same level occurred at similar rates for both groups.
- In focus groups, apprentices reported work at height as their most feared risk involved in their work; fall prevention techniques taught in school, do not necessarily get applied on the work site.
- Younger workers and more seasoned carpenters need fall protection training, and reinforcement of that training, that incorporates ladder and scaffold safety - this should include safe work practices as well as erection and dismantling. Workplace norms must be established that do not allow the inappropriate use of equipment.
- Among these carpenters there were a number of falls related to work surfaces that were not adequately secured or unprotected openings.
- Working on the top plate of a framed wall is a common practice in residential building; when working on the top plate there is not anything to which the carpenter can tie off. However, the work often does not have to be done from there. Use of ladders around the perimeter can

allow the same access without the same risk, as long as the appropriate equipment is used and the ladders are set properly.

- Use of recognized fall protection strategies such as guardrails, toe boards, tying off to an appropriate anchor, and covering openings were all identified by these carpenters as things that could have prevented their falls. However, these practices were not the norm on many sites where falls occurred.
- While work needs to be done efficiently "safety and speed do not mix" particularly when work is being done at height.

Back Injuries

- A significant proportion of back injuries (28.6%), including those with delayed return to work, were the result of acute traumatic injury - falls and being struck.
- Sixty-five percent (65%) of manual materials handling tasks associated with back injury among these carpenters involved a lifting index of over three and over half (52%) had a lifting index greater than five.
- Even among manual material handling back injuries there was some indication that injuries resulting in prolonged loss of time from work were associated with inciting events that created greater acute spinal loads.

Cost data from self-insured homebuilders

- Falls from elevations, which ranked third in frequency, were responsible for the highest costs and the highest costs per claim.
- Although overexertion injuries resulted from multiple tasks, the majority of costs associated with these injuries resulted from two tasks - lifting framed walls and setting steel beams.
- Relatively few injuries involved a worker being caught in or between objects, but these injuries were also responsible for a disproportionate share of costs. The brief text descriptions identified that these high cost events resulted, in large part, from carpenters being caught by walls that fell over. Careful attention to appropriate bracing of walls is indicated.
- Raising and bracing framed walls and handling beams are activities that should be targets for innovative engineering improvements. In the absence of engineering solutions careful attention to adequate manpower to avoid these serious injuries would be prudent. Cranes provide assistance, but injuries result form those as well, and crews and operators must be appropriately trained to use these safely.

Focus Groups

- The common theme on residential sites seemed to be "time is money – and there isn't enough of either." Everyone seems to know how many hours have been allotted to finish a structure, and when they are behind the curve. The perception is that in commercial there are both the time and the money to do things right, but there isn't in residential.
- There was recognition among apprentices that safety is more variable, even negotiable, on residential sites than commercial sites. There was, however, a great deal of variation reported between contractors and foremen. Where things were done right and attention was paid to safety, they were respected.

- These carpenters reported, overall, that most things that should be done are done – somewhere by somebody – but they are not accepted industry wide.
- Consistently work at height was viewed as the most dangerous aspect of residential work, with work from the top plate or "riding the ridge" setting trusses felt to be most dangerous. In contrast, other areas that made significant contributions to falls among these workers -- such as unguarded openings, stairwells or windows -- were not perceived as risky.

USEFULNESS OF FINDINGS

The unique combination of data collected through this effort provided important insights into the magnitude, nature and circumstances surrounding injuries among residential and drywall carpenters-- a group of workers that can be difficult to study due to the nature and organization of their work. Specific examples are cited below. The active injury surveillance, focused on interviews with carpenters by other carpenters allowed in-depth case-based analyses and provided information that is useful in identifying preventive recommendations. Access to work records including hours worked, provided by the union trust fund, also allowed rate-based analyses which were particularly helpful in assessing patterns of risk by union status. The use of text data allowed the exploration of factors not anticipated at the outset of the project and richer detail to enhance our understanding of the injuries and to formulate prevention recommendations.

- Apprentice carpenters, compared to more experienced journeymen, have different patterns of risk for different types of injuries. Some of the risk is not related to experience, but to different work assignments - more use of pneumatic nailers and more manual materials handling responsibilities, for example. Failure to recognize this will lead to continued shifting of some more dangerous tasks, or exposures, to inexperienced workers and attribution of their injuries to inexperience. This consequently leads to a failure to change the exposures with perhaps more emphasis on educating the inexperienced and 'blaming the victims.'
- Falls are a major source of significant morbidity, and mortality, among residential construction workers. All workers on small sites are exposed to work at heights and falls occur from a wide variety of surfaces. Falls are not restricted to inexperienced workers.
- Injuries from pneumatic nail guns are the greatest cause of injuries that result from residential carpenters being struck. The majority could be prevented by use of tools with sequential triggering mechanisms. These data provide evidence that over 65% of injuries associated with contact trip nail guns could likely be prevented by sequential triggers.
- Housekeeping problems contribute significantly to same level falls as well as some struck by injuries, and manual materials handling injuries, and falls from elevations.
- There is a significant need for ergonomic interventions that would reduce back stress on residential and drywall sites. These need to address moving heavy materials and specific tasks such as raising, and bracing, framed walls.
- These data, using actual person-hours of work as the basis for rate calculations, provide additional evidence that injury rates in construction are higher than reported by the Bureau of Labor Statistics. This is even in light of the fact that we know we had less than complete ascertainment of injuries.

RECOMMENDATIONS

- Fall prevention efforts are needed for all levels of workers and contractors that should insure initial training and regular updates and application of site specific fall prevention. Universal application of accepted prevention methods would help tremendously (the covering of openings, use of guardrails around openings and on scaffolding, increased use of slide arresters on roofs, tying off when appropriate anchoring is possible, use of proper ladders and use of ladders properly), but these are not the norm on residential sites.
- Apprentices are not able to effectively use fall prevention strategies they are taught in school without support on the job from more seasoned workers. Apprentices and journeymen recognize differences in application of fall prevention on residential sites compared to commercial work; and differences are often attributed to the speed of the work and emphasis on cost.
- Use of sequential trigger pneumatic nailers on residential sites. The residential construction industry would be well-served by an alliance and collaboration with the trade association (ISANTA) and manufacturers to develop, test and evaluate tool improvements and training programs. Prevention of injuries from pneumatic tools should involve training, engineering and policy changes involving carpenters and contractors, and these efforts should be evaluated and informed by ongoing injury surveillance.
- Assistive devices are needed that can be easily adapted to residential sites to raise framed walls.
- Setting steel I-beams should not be a manual task. Use of a crane for assistance requires special training for crew involved.
- Effective team work and communication are essential in residential construction. These are very important with few workers on site, the use of apprentices at high ratios to journeymen, and the use of crews for assistance that do not always work together.
- Policy changes (union backed and contractor level) to change work norms, safety training and evaluation of the effect of these changes is needed.

SCIENTIFIC REPORT

A. BACKGROUND

Information on the etiology of work-related injuries among construction workers has been limited by practical problems which make the study of their health and safety hazards difficult; these are especially salient when considering those who do residential and drywall work. These are very mobile workforces with individuals frequently changing job sites and even employers. In residential construction, particularly, the duration of work at any given site is shorter in nature than in commercial construction and the nature of the work changes from day to day. Job sites are typically smaller with fewer workers at any given site.

A1. Work-Related Injuries in Construction

Occupational injury rates in the construction trades are high compared to the general workforce in the U.S. The Bureau of Labor Statistics (BLS) (U.S. Dept. Of Labor, 1995) reported an overall rate of lost-time or medical injuries or illnesses of 8.4 per 100 full-time workers in 1994. During the same year a rate of 11.8 per 100 full-time workers was reported among the construction trades. BLS data, the primary source of data on occupational injuries and illnesses in the construction trades, are based on reports from OSHA logs from a probability sample of employers. Employment statistics are used to estimate full-time workers. A cohort approach, using individual person-hours of work time as the denominator, revealed rates of medical cost or lost-time compensation claims for construction carpenters much higher than BLS estimates (Lipscomb, 1996).

Construction workers not only have higher rates of work-related injuries than other trade groups but they are also among the most likely workers to experience serious occupational injuries (Salminen, 1994). Fatal and lost work time injuries in the construction trades continue to rank among the highest in the U.S. (US Dept of Labor, BLS, 1995); Kisner, 1994; Sorock, 1993; Stone, 1993; MMWR 98-04-24). National rates of disabling injuries have risen in the construction trades in recent decades (Robinson, 1988) which is of great concern from human and economic perspectives. The risk of injury does not appear to be equal for all groups of construction workers. Inexperienced workers (< 1 year) have been described as being at greater risk of having a serious work-related injury (Salminen, 1994) as have smaller-size construction employers (Ringen, 1995). However, overall there is a paucity of information on the etiology of these disabling events specific to this population.

A2. Residential Construction and Drywall

Although there are few sources of information specific to residential or drywall construction, there are data that suggest that individuals doing these types of construction are at high risk of injury (Dement and Lipscomb, 1999; Lipscomb et al., 1997; Choui, 1997; Building and Construction Trades Dept, 1997) including high workers' compensation premiums in both of these areas of the trade. Recent costs of workers' compensation insurance coverage in residential one and two family dwellings ranged from just under $10 per $100 of payroll to over $35 per $100 of payroll (Engineering News Record, 1997). Drywall insurance premiums can be as high as $40 per $100 of payroll (Nelson, 1998).

Data from analyses of Washington State workers' compensation claims between 1990 and 1995 revealed that residential construction was ranked as the top construction risk in terms of compensation claims for carpenters (Building and Construction Trades Department, 1997). Residential single family housing had the highest overall absolute number of claims for injuries and illnesses and the fourth highest rate of injury (29.1 per 200,000 hours), behind structural steel, roofing and siding, wrecking and demolition, and glazing. Three types of injuries accounted for 75% of all claims - overexertion, struck by objects, and falls. The Bureau of Labor Statistics does not currently report injury and illness data by a 4-digit Standard Industrial Code (SIC), making it impossible to look nationally at differences in the injury experience of general contractors building single family dwellings (SIC 1521) compared to those involved in residential buildings other than single-family (SIC 1522).

Data from the Construction Safety Association of Ontario summarizing lost-time workers' compensation injuries 1987-88 for 'residential buildings - low rise' (Ontario does not use an SIC designation) is consistent with the data from Washington State. Over 70% of all injuries were described as resulting from overexertion, falls, or being struck by objects. Problems were identified related to housekeeping, manual materials handling, direct installation activities, and on-site in-transit activities that were associated with serious injuries among low-rise residential workers in Ontario. It was felt that these problems could be reduced in a number of ways including better site management, better training, and improved work practices (McVittie, 1995).

Among residential construction workers in N.C. falls from elevations were a major cause of injury with a predominance of falls occurring from roofs, scaffolds, ladders and structural joists and framing. Lifting injuries involving the back and knees were also common. There was evidence that

certain tools were associated with injury including air driven nail guns and metal fasteners, which resulted in hand and eye injuries, and power saws with injuries resulting from contact with the blade and as a result of lumber being "kicked back" (Dement and Lipscomb, 1999). The data did not allow the determination of whether there were problems with tool design or if injuries resulted from improper use.

Rates of traumatic injury resulting in days away from work have been reported to be higher among drywall workers than for all construction workers combined. As in residential construction, drywall workers are at risk of falls and overexertion injuries. In fact falls, bodily reaction, and overexertion injuries have been reported to account for 84% of the total days away from work among these workers. Falls from scaffolds resulted in the greatest lost work days and overexertion was responsible for more lost work days than falls from the same level. One third of trunk injuries occurred while lifting building materials, particularly drywall, and problems were more commonly reported in lifting than in carrying tasks (Chiou and Pan, 1997).

Analyses of workers' compensation claims for musculoskeletal injuries and disorders among union carpenters in Washington State revealed that carpenters affiliated with locals doing predominantly residential work had higher rates of hand and knee contusions and foot fractures than their union counterparts doing heavy or light commercial work, piledriving, or cabinet making. Drywall workers had higher rates of sprains to the shoulder, forearm, knee and ankle. Both of these groups of workers had rates of injuries to the axial skeleton (back sprains, back and neck sprains, back ill-defined conditions) that were twice as high as other union workers (Lipscomb et al, 1997).

All of these reports come largely from analyses of coded data from reported work-related injuries. The American Standard Method of Measuring and Recording Injury Experience of the

American National Standards Institute (ANSI) was accepted in 1937 by employers and the Bureau of Labor Statistics as the standard for recording and reporting work injuries (Pollack et al, 1987). Data based on ANSI codes have been useful for systematically describing injuries and for identifying high risk groups but, as a rule, they do not provide enough descriptive information or detail to identify appropriate preventive strategies.

A3. Work-related Back Disorders

The high rates of injuries to the back among drywall and residential carpenters are not surprising. They have known exposures (Schneider, 1994) to recognized occupational risk factors for back pain - heavy work, materials handling, pushing, twisting, frequent lifting over 25 pounds (4 X 8 sheetrock =80 lbs, 4 X 8 3/4" plywood weighs 60 lbs), requirements for sudden unexpected maximal effort, and work in awkward postures (Andersson, 1981; Damkot, 1984; Frymoyer, 1983; Jacobsson, 1992; Kelsey, 1990; Magora, 1970; Pope, 1988). Demands are increasing for these workers as the use of heavier and bulkier materials increases, such as 12 foot sheets of drywall with weights in excess of 100 pounds per sheet. There is relatively little literature specifically related to occupational back problems among carpenters (Waller, 1989; Waller, 1990; Holmstrom, 1992). Little is known about specific risk factors for injury (ie the inciting event) or the role that cumulative stresses may play in the development and severity of back disorders.

Despite the fact that 10% of industrial back compensation cases have been reported to be responsible for nearly 80% of costs (Spengler, Bigos, et al, 1986), little is known about what differentiates work-related back disorders which result in rapid return to work and those which result in

prolonged periods of work disability. This is an important issue for construction workers who have very high rates of work-related back disorders. Recovery, as measured by return to work, is rapid for the majority of occupational back disorders (Andersson, 1984; Spitzer, 1987; Snook and Jensen, 1984; Spengler and Bigos, 1986), but return to work can mark only the end of the first episode of work disability (Baldwin,1996). There is evidence that back pain tends to be recurrent (Berquist-Uhlmann, 1977; Biering-Sorensen, 1983; Troup, 1981), and a gradual increase in the duration of absence has been reported with successive recurrences (Rossignol, 1992).

Intuitively, the severity of the event/injury would seem to be of importance in predicting long term disability. Yet for back problems few case definitions have been accepted in the scientific community (Wickstrom and Hanninen, 1987). Clinical studies have shown that no more than 50% of patients with low back pain have identifiable structural abnormalities (Damkot, Pope, et al, 1984; Frymoyer, Pope, and Clements, 1983). Measures developed to assess severity of acute trauma are not sensitive enough to grade the vast majority of occupational injuries to carpenters due to a "floor effect". The vast majority of injuries to carpenters treated in the emergency room had an Abbreviated Injury Score (AIS) of 1 indicating a minor injury (Waller, 1989), and this rating had little relationship to the length of time out of work. Hospitalization has been used to control for severity in analyses of disability following work injury (Cheadle, 1994). However, in Waller's study (1989), 74% of carpenters who were still impaired six months after injury had only received outpatient care.

Socioeconomic characteristics and economic incentives have been reported to have significant influence on return to work, as have psychologic, work, and social factors ((Baldwin, 1996; Johnson, 1998; Pope, Andersson, Chaffin, 1991). Disability, in general and among those with work-related

back injuries, is highest among those over age 55, those with an eighth grade education or less, and in those with low income. (Cats-Baril, 1989, Volinn, 1991). Many people continue to have problems which require modification of activities following an episode of back pain (Carey,1995; Von Korff, 1994). Workers in programs that provide modified duty jobs have been reported to have decreased disability periods (Ryden, 1988; Wiesel, 1994), raising questions about whether modified work arrangements are reasonably available for construction workers whose tasks involve predominantly heavy work.

A4. Current Project

To explore some of these issues, an active injury reporting and investigation system was initiated for a large group of union drywall and residential carpenters in St Louis, Missouri - the only area in the United States with a large unionized residential workforce. This was done to document the magnitude of injuries among this group and to describe in more detail the nature of their injuries and the circumstances surrounding these events. The focus of this surveillance effort was on the identification of factors or circumstances that could have prevented the injury. This approach is modeled after the NIOSH Fatalities Assessment Control and Evaluation (FACE) program.

In addition to the NIOSH FACE program, case investigations have been used by a number of different groups and individuals to identify causal factors and contributing circumstances for injuries. The BLS surveyed workers identified through the Supplemental Data System in their Survey of Work Injury Report Survey Program to explore causes of specific types of work-related injuries (US DOL, 1986). These mailed questionnaires were designed to obtain information on the circumstances

surrounding the injury, work site conditions or other factors contributing to the injury, safety practices and employee experience and training (Pollack, 1987). Departments of motor vehicles routinely use "accident" investigations. While these investigations serve legal purposes, the detailed data collected regarding the circumstances of motor vehicle accidents has been used to identify circumstances leading to injuries and things that could have been done to prevent injuries. A classic example comes from analyses of investigations of motor vehicle accidents resulting in fatalities among young children in medical examiner files. This work done by Susan Baker identified the, now well recognized, danger of infants sitting on the laps of adults in motor vehicles (Baker, 1979).

To explore risk factors for prolonged loss of time from work after a back injury among these high risk construction workers, comparisons were planned between injuries, and workers experiencing these injuries, which resulted in rapid return to work and those which resulted in more prolonged work absence (> 1 month). Part of this was to involve the creation of profiles of cumulative exposure to low back injury stressors and biomechanical characterization of the inciting event that lead to the low back injury. This work relied heavily on the results of a previous NIOSH-supported research project (RO1-CCR413061 "Back Injury Interventions for Small Contactors" PI: G Mirka) completed in 1999. The specific activities of that previous work that were pivotal in the current work were those efforts focused on the development of the Continuous Assessment of Back Stress (CABS) methodology, an approach to quantifying low back injury risk by using multiple risk assessment tools and presenting the results of this work in the form of probabilistic distributions describing the relative amount of time spent at different levels of biomechanical stress.

A5. Specific Aims

This project involved collaborative efforts among the Division of Occupational and Environmental Medicine at Duke University Medical Center, The Industrial Engineering Department at North Carolina State University, the Health and Safety Fund of the United Brotherhood of Carpenters (UBC) and Joiners of North America, and the St. Louis District Council of the UBC and their participating contractors. This district council represents a large work force of unionized drywall and residential carpenters. The objectives of the project were to test the utility and feasibility of active injury investigations in identifying causes of work-related injury among this group of workers with very high injury rates. Additionally, specific risk factors for occupational back disorders that result in prolonged loss of time from work would be explored with a case-control design which used data gathered prospectively through reporting and investigation. The specific aims of the project included the following:

- Identify a cohort of drywall and residential carpenters to participate in a prospective study of the etiology of workplace injuries.
- Develop methods for the prospective reporting of injuries, the systematic collection of data from injury investigations, and the analyses of both coded and descriptive data.
- Conduct both rate-based and case-based analyses of injuries among the defined cohort of drywall and residential carpenters. These analyses have the specific objective of identifying high risk groups and causes of injuries.
- Demonstrate the use of these prospectively collected data in exploring risk factors for prolonged loss of time from work following back injury using a case-control design.

B. MATERIALS AND METHODS

We report on an active injury surveillance project designed to test the utility and feasibility of active injury investigations in identifying causes of work-related injury among a large cohort of residential and drywall carpenters. The program was designed to document the magnitude of injuries among these carpenters, to describe in detail the nature of their injuries and the circumstances surrounding these events.

B1. Site of work

This active injury surveillance project was conducted in the area surrounding St. Louis, Missouri; this is the only area of the United States with a large unionized workforce of residential carpenters. The work was done through a partnership with the Carpenters' District Council of Greater St. Louis and the Homebuilders Association of Greater St. Louis. Contractors were recruited to participate in the project, agreeing to report all OSHA recordable injuries (injuries requiring medical care above first aid, loss of consciousness, or loss of work time beyond the day of injury) to the project office by facsimile or phone message as they occurred on their work sites. A steering committee was established early in the project with representation from the union, contractors, contractors' safety personnel, and the academic research team. This committee helped design the surveillance protocol which is described in more detail below. To increase name recognition over time the project was named the St. Louis Injury Prevention Project, or ***SLIPP.***

B2. Investigation Methods

The investigation approach was modeled after the National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment Control and Evaluation (FACE) program. However, in contrast to FACE which only investigates fatalities, we were primarily interested in the bulk of work-related injuries that do not result in death. Injured carpenters were interviewed by one of two experienced journeymen carpenters. These men had, respectively, 42 and 25 years of carpentry experience and OSHA 500 training; they were trained in procedures to obtain informed consent and a standard questionnaire protocol for investigation of these injuries. Although they followed a standard protocol for collection of data, the investigators asked additional questions, as needed, to provide sufficient detail to understand the circumstances surrounding these injuries and to form opinions as to contributing factors.

As injuries were reported, the injured worker was called by one of the investigators and approached about participation in the study. After informed consent was obtained, interviews were typically conducted by phone. Questions were asked about the nature of the injury, the circumstances surrounding the injury, what the worker was doing, tools and materials being used, the stage of the construction project, time in the union, age, gender, safety training, use and availability of personal protective equipment, weather conditions, stand-by exposures, and work of other trades on site. The carpenter was also asked what they felt caused or contributed to their injury and what they thought could have prevented the event from occurring. After the interview, the investigating carpenter also reported his assessment of contributing factors and possible preventive recommendations.

When the injury was the result of a fall, a site visit was also made to assess fall hazards and measures of the overall safety climate on the site using a checklist developed by the steering committee. The site visit tool is presented in more detail in Section C3. *Injuries from Falls*. Both the investigation interview and site visit checklist are in Appendix A.

B3. Definition of Time at Risk

Union carpenters receive health insurance and retirement benefits through jointly trusteed health and welfare funds. Contractors hiring union labor pay into the trust based on hours worked by the carpenters working for them. The local trust provided us with the hours worked per carpenter by contractor for each month, allowing us to calculate time at risk. The trust also provided information that allowed us to determine whether hours worked were by an apprentice or a journeyman carpenter.

B4. Nature of Data and Management

The combination of data, described above, allowed the definition of a dynamic cohort of carpenters, their hours worked, detailed information on OSHA recordable injuries and the circumstances surrounding these injuries. We were also able to collect information on possible preventive measures from the perspective of the injured worker, as well as through the eyes of an experienced journeyman investigator. The interview data consisted of a mix of variables that could easily be coded and free text information describing the circumstances and possible preventive measures. These data were entered into an ACCESS (Microsoft, 1997) relational database. Codes were assigned for body part injured, nature of the injury, the mechanism or type of the injury using

modified ANSI coding categories common to workers' compensation data. Drawings, illustrating specific conditions or circumstances provided for some of the investigations, were scanned and added to the database linked to the appropriate investigation.

B5. Focus groups

A series of 10 focus groups involving 65 carpenters were conducted; 54 apprentices and 11 journeymen were included in the groups. Groups with apprentices and journeymen were conducted separately. Apprentices were asked about career decisions, job site conditions, safety responsibility, progression of tasks and responsibilities as an apprentice, dangerous task training opportunities, supervision and mentoring, safety training and use of personal protective equipment (PPE), perception of risk, job stressors, and suggestions about thing that would improve the apprenticeship program. One goal of these groups included gaining a better understanding of work exposures of apprentices and how they differ from those of more experienced carpenters. The focus group with journeymen concentrated on issues related to how more experienced carpenters work with and mentor apprentices. The focus group discussion guides are in Appendix B.

B6. Analyses

Descriptive statistics were generated on the age, gender, and union status (level of apprenticeship training vs journeymen) of the dynamic cohort, and for the coded variables from the worker interview. The sum of hours worked by the entire cohort between September 1, 1999 and September 30, 2002 was calculated; hours worked were also stratified by five-year categories of age,

gender, and union experience level. Crude and stratified injury rates were calculated per 200,000 hours worked (100 person-years of FT work). The overall injury rates were calculated using all reported injuries; stratified rates, dependent on information from the interview for classification, were limited to data from injured carpenters who participated in the interview. Confidence intervals were calculated as described by Haenszel et al., assuming a Poisson distribution (1962).

Records were sorted by primary mechanism of injury (fall vs manual materials handling injury, for example). Text descriptions of the injuries were reviewed to identify more common patterns and circumstances of injury. A progressive series of queries and cross-tabulations, followed by re-sorting of data and review, assisted in this process. Analyses were done through a series of ACCESS queries and export of data to SAS (Version 8, 1999).

The focus groups were audio-recorded and transcribed. The transcripts were imported into N5 software (QSR, 2000). A node structure was defined to allow systematic cataloguing of key concepts based on the focus group interview guides.

Falls and back injuries were a priori areas of particular interest, as designated in the specific aims of the project. Early in the project it became obvious that injuries from pneumatic nail guns were a significant problem among these carpenters. In addition, as different injuries were examined, it became obvious that injury patterns varied not only by time in the union, but by the type of injury experienced, leading to more detailed comparisons of patterns of risk between apprentices and journeymen. Lastly, analyses were conducted of workers' compensation data from a group of six self-insured homebuilders who agreed to provide access to their records for the years 1996-2000 to

supplement the active injury surveillance. The latter data provided information on costs associated with injuries which was not available through the active surveillance effort.

Analyses were conducted and reported on a regular basis through *The Cutting Edge*, the monthly newsletter of the Carpenters District Council of Greater St. Louis and Southern Illinois. The newsletter is sent to a readership of over 20,000 which includes all carpenters represented by the CDC and affiliated contractors. Articles are included in Appendix C.

RESULTS

C1. Overview

Description of the Carpenter Cohort and Hours Worked

The dynamic cohort consisted of 5,137 carpenters who worked for one of 20 participating contractors. These contractors hired a total of 9,346,603 carpenter hours from September 1, 1999 through September 30, 2002. Characteristics of the cohort are presented in Table C1:1. In this area, union carpenters hang, but do not finish, drywall on commercial and residential sites. Residential carpenters frame and sheath roofs, but do not do shingling.

Injuries Investigated

Between September 1, 1999 and September 30, 2002 a total of 783 injuries were reported in residential or drywall work among participating contractors. Of these, 586 injured carpenters participated in injury investigation interviews (74.8%). We were unable to locate 75 injured carpenters, making the participation rate 84.3% among those we were able to reach. Interviews were conducted from the day of injury up to 202 days after injury (mean 19.0, median 9, mode 6.) The very long follow-up period resulted from inadvertent failure to report injuries as they occurred by a contractor during a period of office staff change.

Four hundred thirteen (413) injuries occurred on residential single family sites (70.5 %), including 4 boat houses and one remodeling job, and 90 (15.4%) occurred on multi-family residential projects. There were 80 (13.7%) injuries that occurred on commercial drywall sites. The remaining 3 injuries were attributed to cumulative exposure by the carpenter and were not assigned a specific

project type. The stages of the construction at the time of these residential injuries are presented in Table C1:2. Over 50% of injuries occurred in residential framing, followed by exterior and interior finish.

The mechanism of injuries are presented in Figure C1:1. Injuries were most commonly caused by the carpenter being struck by or against something, manual materials handling tasks or some other type of overexertion, falls from elevations, and falls from the same level. Detailed analyses of falls are presented in Section C3.

Primary body parts injured are presented in Figure C1:2. Injuries involved the upper extremities over 40% of the time followed by the lower extremity, axial skeleton/trunk, and the head and face including the eyes.

In Table C1:3 the nature of the injuries sustained are presented by mechanism of injury. The injuries that resulted from being struck by or against something were largely cuts, puncture wounds, scratches/abrasions (including eye injuries), and contusions (87%). Nearly 90% of the overexertion injuries resulted in sprains and strains. Falls from height and same level falls most often resulted in sprains/strains or contusions, but 26% and 17% of these falls, respectively, resulted in fractures. During this 37 month period, 14 cases were reported as being the result of repetitive activity. Injuries that resulted from being caught by something were similar to the struck by injuries. They varied from cuts sustained by getting caught against a protruding nail to being caught under a framed wall that fell. Although there were few of these injuries, two of ten (20%) resulted in fractures.

Seven heat-related events requiring medical treatment were reported -- six in the late summer of 2001 and one in the summer of 2002. An alert was sent to the union and participating contractors in the summer of 2001 and again in late spring 2002 (see Appendix C).

The objects that carpenters were struck by or against are presented in Table C1:4. The most common objects carpenters were struck by were nails or nail pieces (n=92). The majority of these came from pneumatic nail guns, resulting in puncture wounds and fractures. The next most common objects included dust and debris, that resulted in eye injuries; and power tools and metal bands used to bundle materials on construction sites, that resulted in cuts. There were a number of very heavy objects that hit these carpenters including steel I-beams, boards, scaffolding, joists, rafters, plywood, drywall, and framed walls.

Materials being handled at the time of overexertion injuries (n=87) were most commonly associated with handling of building materials (Table C1:5). For 83 (95%) of these objects weight was estimated; the carpenter was handling an object weighing greater than 100 pounds 48% of the time (n=40) and 200 or more pounds 28% of the time (n=23).

Over half the time when overexertion injuries occurred the person was working alone (n=52). In 20 cases (23%) the load was unexpected, and in 47 cases (50%) the carpenter reported working in an awkward posture when injured.

Carpenters fell from a wide variety of surfaces most commonly ladders, scaffolds and unsecured work surfaces. The scaffolds were predominantly two types; platform scaffolds, such as Perry or Baker's scaffolds, and pic boards (lumber working platforms) set on ladders or horses. Same level falls were often related to weather, housekeeping or terrain issues, such as tripping over debris, difficult work terrain (rocky, muddy, uneven); the slope of lot, lack of backfill around the foundation, difficult access, and/or egress from the building. Housekeeping was commonly reported to be the job of laborers. Site cleanup was reported at variable frequencies ranging from daily to after each stage of

the project, such as when framing, was complete. Knowledge of a housekeeping policy on site was reported by 307 (52.5%) of the injured workers; while 467 (82%) reported that there was a designated area for debris. Occasionally, housekeeping was assigned to apprentice carpenters and was on an "as you go basis." More detailed analyses of falls from height and same level falls are presented in Section C3.

C3. Characteristics of Injured Workers

All of the injured carpenters were men. Their ages ranged from 18 to 62 with a mean of 32 years and a median of 31 years. Time in the union ranged from less than one year to 41 years (mean 8.2 years, median 4 years); 258 were apprentices and 326 were journeymen.

Reported awareness of on-site safety programs are presented in Table C1:5. Over 75% reported some awareness of a safety program, most commonly weekly, or bi-weekly, tool box talks. Workers who were aware of safety programs had been on the job site longer (18.2 days vs. 10.6 days; $p=0.07$), and they had worked for the contractor longer than those who were not aware of any safety program (mean 57.4 months vs 33.9 months; $p<0.0001$).

Workers were also asked about availability of specific items of personal protective equipment (Table C1:7). The availability of hard hats and safety glasses or goggles were reported by almost all of the injured carpenters, followed closely by guardrails.

Estimated Rates of Injury

The estimated overall injury rate was 16.8 per 200,000 hours worked (783/9.3 million hours). There were 290 injuries that resulted in lost time from work beyond the day of injury (50% of those interviewed; data item missing for 37), representing a lost-time injury rate of 6.3 per 200,000 hours worked based only on individuals who were interviewed. If those who participated were representative of the pool of injuries, this rate would be as high as 8.4 per 200,000 hours.

The injury rate among apprentices was 16.3 per 200,000 hours worked (95% CI 14.3 to 18.4) compared to 10.8 per 200,000 hours worked (95% CI 9.7 to 12.1) among journeymen (RR=1.5). Rates for the major mechanisms of injury are compared by union status in Table C1.8. Rates were significantly higher overall among apprentices and for injuries that resulted from being struck by or against something (RR=1.9). Nail gun injuries, in particular, occurred at rates 3.1 times higher among apprentices. (Nail gun injuries are described in more detail in Section C2: *Injuries from Pneumatic Nail Guns and Staplers*.) Overexertion injuries overall occurred at similar rates for apprentices and journeymen. However, apprentices had back injury rates that were 50% higher than journeymen and knee and shoulder injuries that were lower. The latter rates, and the remaining categories, are based on small numbers resulting in wide confidence intervals.

Prevention Recommendations of Workers and Journeymen Investigators

In Table C1:10 responses of injured carpenters to specific queries about contributions to their injuries are summarized by major mechanisms of injury. Time pressures and speed of work were the most common factors carpenters acknowledged.

There was considerable variation in these responses by type of injury. Forty-seven percent (47%) of workers who experienced a same level fall felt time pressures contributed to the circumstances leading to injury, and 20% attributed housekeeping issues. Overexertion injuries were most often attributed to the task being too heavy (34%) or the carpenter needing help (25%).

Although some carpenters had no specific preventive suggestions, saying they should have "been more careful" or "it was just an accident," more specific preventive recommendations were gleaned from the majority. The importance of effective communication among crew members was raised by carpenters who sustained all types of injuries. Carpenters reported problems on days when new crew members were with them, they had assistance from another crew, or their usual apprentices were in class.

These carpenters quickly accepted responsibility for their own injuries, reporting things they might have done differently. Examples are presented by mechanism of injury in Table C1:10. They cited specific tasks that they felt required more help, or assistive devices, such as a crane. These included setting steel I-beams, raising walls, and setting large windows. Comments were made about difficulty managing pic boards on ladder jacks, feeling pump jacks were safer to handle. Workers often mentioned debris being in their way, blocking holes or making it difficult to carry heavy or awkward objects. They also reported concerns about keeping their jobs and hesitancy to ask for more help or to stop in bad weather, for example. These men recognize that they will work in less than perfect weather, but also report certain tasks that should be avoided, such as roof work on rainy or icy days.

The preventive recommendations of the journeymen investigators were often in agreement with the injured worker. However, the investigators were more likely to think the injured individual could

have benefitted from more task or safety training, that personal protective equipment (safety glasses, gloves, etc.) would have helped, housekeeping could have been improved, or that time pressures were likely a factor.

Discussion

Summary of Findings

The pattern of injuries among these carpenters was as expected - commonly involving being struck by or against something, overexertion, and falls. Injuries from pneumatic nail guns were the most common cause of injuries in which a carpenter was struck. Manual materials handling injuries often involved very heavy objects and tasks - setting of I-beams, trusses, pre-manufactured beams, or sheets of 16 foot drywall, for example. This was compounded by the fact that there are few workers on any given residential site. Acute injuries were predominantly associated with this very heavy work, although the contribution of stress over time could not be measured. The pattern of higher back injury rates among apprentices is not consistent with longer term cumulative stress; while the pattern of higher injury rates involving the shoulder and knee among journey men is consistent with a possible cumulative stress contribution.

Falls occurred from a variety of surfaces making prevention challenging. The injuries that resulted from falls, as well as those from being caught, tended to be more severe. Poor housekeeping was involved in circumstances leading to the many injuries resulting from same level falls, as well as some overexertion injuries - particularly moving large objects where view was obstructed. On residential sites, injuries most commonly occurred in framing followed by exterior and interior finish and

then roofing, a likely reflection of the time union carpenters spend working in these stages in constructing homes.

The overall estimated injury rate (16.8 per 200,000 hours worked) is considerably higher than recent Bureau of Labor Statistics (BLS) rates (USDOL, 2002 for the construction trades (8.3 per 200,000 hours worked) despite the fact that there was less than complete ascertainment of injuries. Injury rates higher than those reported by BLS have been reported previously among union carpenters in the State of Washington, (Lipscomb, 1996) and by Glazner et al., (1998) in the building of the Denver International Airport. These studies, representing commercial and residential sectors, also used hours worked as measures of time at risk, whereas BLS rates are based on estimates of aggregate hours for the sector.

Consistent with past BLS attempts to survey workers about their injuries (USDOL, 1986), these carpenters were quick to accept responsibilities for their injuries – even when it appeared the injury may have been caused by others or involved multiple-factors. Lack of awareness of on-site safety programs was associated with less time on the site and working for the contractor. This finding is unlikely to be due to biased reporting from injured workers in light of their acceptance of responsibility and the associations with time on site and experience with the contractor.

Limitations and Strengths

At times absence of staff responsible for reporting injuries resulted in late or under-reporting. There likely was some failure to report due to inconvenience, or not wanting to report, and the latter particularly could create bias. One large drywall contractor chose to ask all workers if they wanted to

participate before reporting any injuries. Obviously, no information was available about injuries the carpenter chose not to report as work-related. No information was available on exposures of the uninjured members of the cohort and thus, injury rates could not be calculated by exposure to specific tasks or tools.

Since this was an entirely union workforce, questions arise as to whether the experience of union carpenters is generalizable to a non-union environment. Union carpenters receive training through established apprenticeship programs. They also might be less likely to report injuries since they have other insurance coverage through the union. Davis et al. (2001), reported that union workers are more likely to report musculoskeletal disorders earlier; however, few of these were seen. The project was conducted with predominantly large contractors (hiring a mean of 80 full-time carpenters per year) who may have more resources for health and safety than smaller contractors. Higher rates may have been seen under different circumstances.

Rapid evaluation is difficult to achieve even under these circumstances, and this level of surveillance is time consuming. The interviews with injured workers took a minimum of 20 minutes to complete. Much of the interview involved closed ended questions based on knowledge from earlier analyses of compensation records (Lipscomb, 1996; Dement and Lipscomb, 1999). However, it was felt to be important to understand in detail the circumstances surrounding injuries among this group of workers who are difficult to study, resulting in open ended items and text data with which to deal. An OSHA reportable definition was used for this project to ease the administrative burden on participating contractors and to capture a fuller understanding of all injuries. To decrease costs involved, a threshold for data collection could be established.

The only information available on the injuries came from interviews with workers done shortly after injury. While this provided some idea about severity, particularly for devastating events, severity can be difficult to quantify at this early stage. Better severity measures could be particularly useful in trying to establish priorities for prevention (Lipscomb, 2001).

Despite these limitations, there are also a number of strengths to this approach. High participation rates among injured workers are likely a reflection of the investigations having been done by fellow union carpenters, who have in-depth knowledge of situations encountered in the field and were able to quickly establish rapport with the injured carpenters. These data come directly from injured workers - a perspective that is important, not just in understanding events, but in planning interventions. At the outset there was concern that the process would lead to blaming of contractors. Patterns are not suggestive of this and, in fact, workers were quite willing to take responsibility for their own injuries – even at times when the trained investigators felt there were other explanations for the events. They reported circumstances when the contractor bore some responsibility, but this was, by no means, across the board.

Conclusions

Active surveillance, such as this, yields information on factors that contribute to injuries among high risk construction workers who are difficult to study for practical reasons. The process is more time consuming than passive surveillance activities, but the information is more useful for understanding the circumstances surrounding injuries and in formulation of concrete preventive recommendations.

Rapid feedback to those "who need to know" from the Centers for Disease Control and Prevention surveillance definition (USDHHS, 1987) is more likely to occur in a meaningful manner.

Construction is dangerous work and despite a decline in injury rates over time, these data support the notion that it may be more dangerous than recognized. Unfortunately, many injuries are still viewed as accidents - random events that "just happened". Increased awareness to the contrary is needed among workers and contractors.

Key Points and Recommendations

Based on this surveillance effort, a number of recommendations for prevention can be made including the following.

- Fall prevention needs to target all residential and drywall carpenters. These potentially devastating events are not just injuries of inexperience.
- Use of power tools, like pneumatic nail guns, cannot be assumed to be unskilled tasks that can safely be assigned to new workers.
- Housekeeping is a major issue contributing to injuries in residential and drywall carpentry. In the union work environment, site housekeeping is typically the responsibility of laborers, not carpenters, and this is dictated by negotiated work agreements. This has the potential to create safety problems on work sites. Appropriate agreements about housekeeping frequency and responsibility could benefit workers. Some housekeeping activities, such as removal of metal materials bands, should be part of routine work.
- To safely do this work adequate manpower is needed, trained to work effectively as a group. This has important implications with apprentices on job sites and new workers in a non-union environment. It cannot be assumed that new or inexperienced workers know how to fit in the group as effective team members. It is not uncommon to call in other crews to help with very heavy tasks – involving men or women who may not have worked together. Direction of a crew in complex tasks and mentoring of less skilled crew members are crucial to safely doing this work. This is a skill that is not necessarily taught to carpenters.
- There are needs for engineering improvements in residential construction and drywall installation. Workers need assistive devices that are easy to set up, move and adapt to terrain differences. Residential sites are unlike commercial sites where equipment can be placed for months at a time. It is possible that information technology could be adapted to predict or track needs of workers at different sites, at least allowing for planning at the sub-division level.

Table C1:1 Characteristics of carpenter cohort, union carpenters, 1999-2002

	Overall	Residential	Drywall
Gender			
Male	5110 (99.5 %)	4340 (99.7 %)	1,056 (98.7%)
Female	15 (0.29%)	11 (0.25%)	4 (0.37%)
Unknown	12 (0.23%)	2 (0.05%)	10 (0.03%)
Age[1]			
Mean	32.7 years	32.3 years	35.1 years
Range	18-71 years	18-67 years	18-71 years
Median	31 years	31 years	35 years
Hours by union status[2]			
Apprentice	3,160,230 (33.8%)	2,737,227 (35.4%)	423,003 (26.3%)
Journeymen	6,047,468 (64.7%)	4,895,386 (63.3%)	1,152,082 (71.7%)
Missing	138,905 (1.5%)	1,036,804 (1.4%)	32,101 (2.0%)

1 Age at time of first observation

2 Count changed over period of observation as some apprentices became journeymen; therefore distribution of hours reported.

Table C1:2 States of residential construction at the time of injury, union carpenters, 1999-2002

	Frequency (percent)	
Residential Stage		
Ground breaking/layout	1	(0.2)
Foundation	20	(3.4)
Framing	312	(53.2)
Roofing[1]	37	(6.3)
Interior finish, not drywall	29	(8.5)
Drywall	20	(3.9)
Exterior finish	47	(10.5)
Other[2]	24	(4.1)
Total	**586**	**(100.0)**

1 Residential carpenters do roof sheathing, not shingling.

2 Includes repetitive and cumulative exposure injuries, remodeling, demolition, punch-list activities, shop-related, motor vehicle related.

Table C1:3 Nature of Injury by Mechanism, Union Residential and Drywall Carpentry, 1999-2002

		Frequency (percent)
Mechanism of Injury	**Nature of Injury**	
Struck by or against	Cut	122 (37.0)
	Puncture wound	90 (27.3)
	Scratches/abrasions	45 (13.6)
	Contusion	35 (10.6)
	Fracture	16 (4.8)
	Sprain/strain	8 (2.4)
	Eye foreign body	7 (2.1)
	Amputation	3 (0.9)
	Others[1]	4 (1.2)
	Total	**330** (100)
Overexertion	Sprain/strain	86 (89.3)
	Hernia	2 (2.4)
	Fracture	2 (2.4)
	Torn cartilage/meniscus	2 (2.4)
	Others[1]	6 (3.6)
	Total	**98** (100)
Falls from Height	Contusion	26 (30.0)
	Sprain/strain	24 (27.6)
	Fracture	23 (26.4)
	Cut	8 (9.2)
	Dislocation	2 (2.3)
	Concussion	2 (2.3)
	Multiple injury	1 (1.1)
	Chipped tooth	1 (1.1)
	Total	**87** (100)
Same Level Falls	Sprain/strain	12 (40.0)
	Contusion	11 (36.7)
	Fracture	5 (16.7)
	Others[1]	2 (6.7)
	Total	**30** (100)
Repetitive Activity	Carpal tunnel syndrome	7 (50.0)
	Ganglion cyst	2 (14.3)
	Others[1]	3 (21.5)
	Total	**14** (100)
Caught	Sprain/strain	5 (50.0)
	Fracture	2 (20.0)
	Cut	2 (20.0)
	Concussion	1 (10.0)
	Total	**10** (100)

Note: Heat-related, electric shock, and stings/bites are not included.

[1] Single observations only

Table C1:4 Objects Carpenters were Struck by or Against, Union Residential and Drywall Carpentry, 1999-2002

	Frequency (percent)
Fasteners	
Nail/piece of nail	92 (27.9)
Staples/screws	8 (2.4)
Drive pin from powder actuated tool	1 (0.3)
Materials	
Boards (variety of sizes)	15 (4.5)
Joist (includes para-.microlam)	8 (2.4)
I-beam, steel	6 (1.8)
Plywood	10 (3.0)
Others[1]	5 (1.5)
Metal Materials	
Band iron	17 (5.2)
Framing track	5 (1.5)
Metal stud	7 (2.1)
Cornerbead	4 (1.2)
Joist hanger	3 (0.9)
Others[1]	16 (4.8)
Equipment	
Ladder	2 (0.6)
Bakers' scaffold	1 (0.3)
Hand Tools	
Utility knife	14 (4.2)
Hammer	8 (2.4)
Sledge hammer	1 (0.3)
Power Tools	
Power saws (blade)	23 (7.0)
Others[1]	8 (2.4)
Pre-constructed components	
Walls/partitions	6 (1.8)
Cabinet/doors	3 (0.9)
Others[1]	2 (0.6)
Debris	
Sawdust/dirt/chips	26 (7.9)
Splinters	8 (2.4)
Metal shavings	9 (2.7)
Miscellaneous Others[1]	22 (6.7)
Total	**330 (100)**

[1] Single observations only

Table C1:5 Objects Associated with Manual Materials Handling Tasks, Union Residential and Drywall Carpentry, 1999-2002

	Frequency (percent)
Building materials	
Boards/lumber	19 (21.8)
Trusses/joists (Includes laminated beams)	16 (18.4)
Drywall sheets	8 (9.2)
Steel I-beams	7 (8.0)
Plywood sheets/particle board	5 (5.7)
Siding (masonite, vinyl)	3 (3.4)
Trim/molding	3 (3.4)
Bricks/blocks	2 (2.3)
Box of nails	1 (1.1)
Metal studs	1 (1.1)
Plaster	1 (1.1)
Total	**66 (75.9)**
Equipment	
Pic board (platform for ladder jack)	5 (5.7)
Ladder (extension)	3 (3.4)
Ladder and pic	1 (1.1)
Cords	1 (1.1)
Concrete forms	1 (1.1)
Total	**11 (12.6)**
Pre-constructed components	
Doors	3 (3.4)
Vanity (oversized, marble)	2 (2.3)
Cabinet	2 (2.3)
Framed wall	1 (1.1)
Desk	1 (1.1)
Refrigerator	1 (1.1)
Window	1 (1.1)
Total	**11 (12.6)**
Overall total	**87 (100.0)**

[1] Single observations only

Table C1:6 Reported Awareness of On-site Safety Program, Injured Union Residential and Drywall Carpenters, 1999-2002

	Frequency (percent)*
Awareness of On-site Safety Program	421 (75.7%)
Designated safety person	367 (62.7%)
Hazard communication	329 (56.2%)
Fall protection plan	309 (52.8%)
Safety manual	299 (51.1%)

*percent of those who responded to question

Table C1:7 Reported Availability of Personal Protective Equipment, Injured Union Residential and Drywall Carpenters, 1999-2002

	Frequency (percent)*
Hard hats	570 (98.5%)
Safety glasses or goggles	535 (94.2%)
Guardrails	500 (90.9%)
Safety belt/harness and/or lifelines	303 (61.1%)
Ear plugs or other hearing protection	344 (64.1%)
Gloves	221 (42.3%)
Back belts	84 (31.9%)
Aprons	4 (3.1%)

*percent of those who responded to question

Table C1:8 Work-related Injury Rate^ Estimates for Primary Mechanisms of Injury by Union Status, Active Injury Surveillance Union Residential and Drywall Carpentry, 1999-2002

	Rates^ (95% CI) [n]		
Mechanism of Injury	**Journeymen**	**Apprentices**	**Rate Ratio***
Struck by or against	5.5 (4.7, 6.4) [167]	10.3 (8.9, 12.2)[162]	1.9 **
Nail guns	1.2 (0.80, 1.7) [29]	3.7 (2.7, 4.9) [51]	3.1**
Overexertion	2.1 (1.6, 2.7) [63]	2.2 (1.5, 3.1) [35]	1.1
Back	0.86 (0.55, 1.3) [26]	1.3 (0.79, 2.0) [20]	1.5
Shoulder	0.27 (0.12, 0.53) [8]	0.19 (0.04, 0.55) [3]	0.70
Knee	0.30 (0.14, 0.59) [9]	0.19 (0.04, 0.55) [3]	0.63
Falls from Height	1.6 (1.2, 2.1) [49]	2.4 (1.7, 3.3) [38]	1.5
Same Level Falls	0.63 (0.30, 1.2) [20]	0.66 (0.40, 1.0) [10]	1.0
Caught	0.23 (0.09, 0.47) [7]	0.19 (0.02, 0.55) [3]	0.82
Repetitive Activity	0.40 (0.21, 0.70) [12]	0.13 (0.02, 0.46)[2]	0.33
Overall	**10.8 (9.7, 12.1)** [326]	**16.3 (14.3, 18.4)** [258]	**1.5 ** **

^ Rates are per 200,000 hours worked; based on interview data; estimate 20% higher if respondents are representative.

* Ratio apprentice/journeymen

** Statistically different from 1 at 0.05 level of significance

Table C1:9 Factors Reported by Carpenters to be Associated with Injury by Injury Mechanism
Active Injury Surveillance Union Residential and Drywall Carpentry, 1999-2002

	Mechanism of Injury						
Conditions/factors that contributed to injury	**Struck by or against (n=330)**	**Over-exertion (n=98)**	**Same level fall (n=30)**	**Fall from height (n=87)**	**Repetitive activity (n=14)**	**Caught (n=10)**	**Overall (N=586)**
Housekeeping	6%	10%	27%	7%	7%	0%	7%
Lighting	2%	1%	7%	0%	0%	0%	2%
Slippery surfaces	5%	16%	47%	21%	2%	10%	11%
Storage of materials	4%	5%	0%	2%	7%	0%	3%
Time pressures	16%	18%	10%	21%	29%	20%	17%
Weather	10%	8%	40%	14%	14%	20%	13%
Co-worker	11%	10%	0%	10%	0%	20%	10%
Fatigue	5%	8%	7%	2%	7%	0%	6%
Speed of work	20%	15%	3%	21%	14%	20%	18%
Task too heavy	3%	34%	0%	1%	21%	20%	8%
Needed training	2%	2%	0%	1%	0%	0%	2%
Wrong tools for task	5%	4%	0%	0%	0%	0%	4%
Needed help	4%	25%	0%	4%	7%	0%	7%
Delivery of materials	2%	9%	3%	6%	14%	0%	4%

* Percent of those answering this item.
Note: Categories are not mutually exclusive

Table C1:10 Preventive Recommendations Made by Injured Carpenters by Mechanism of Injury

Mechanism of Injury	Preventive recommendations
Struck by	• Use eye protection: goggles for overhead work, especially. • Un-hook tools from power supply before working on them. • Training in use of power tools for apprentices • Cut metal materials bands with snips and bend them over to avoid cut hazard; throw away when able to remove them. • Adequately brace framed walls
Overexertion	• Use assistive equipment: levers, lift devices, cranes • Get proper help for heavy tasks • Do not push so hard • Work as a team for heavy tasks
Fall from same level	• Install cleats on walk boards • Improve grading of site early in project • Increase frequency of site housekeeping • Backfill foundation early
Fall from height	• Check integrity of all work surfaces; scaffolds, ladders, sub flooring, roof, joists, top plate of framed wall • Improve ladder safety: check frequently for proper condition, tag and replace damaged; use appropriate ladder for task; be sure long enough; secure on surface, tie or brace if needed. • Use more fall protection: more toe boards, guardrails, tie off more • Use cranes to avoid some risks; setting I-beams, large windows • Cover and mark openings • Replace pic boards and ladder jacks with pump jacks
Caught	• Secure adequate help to raise framed walls • Use assistive devices, cranes to "set steel" • Put something (like blocks) under anything heavy as you build to avoid having to get under it to lift

Figure C1:1 Mechanism of Injury, Active Injury Surveillance Union Residential and Drywall Carpentry, 1999-2002

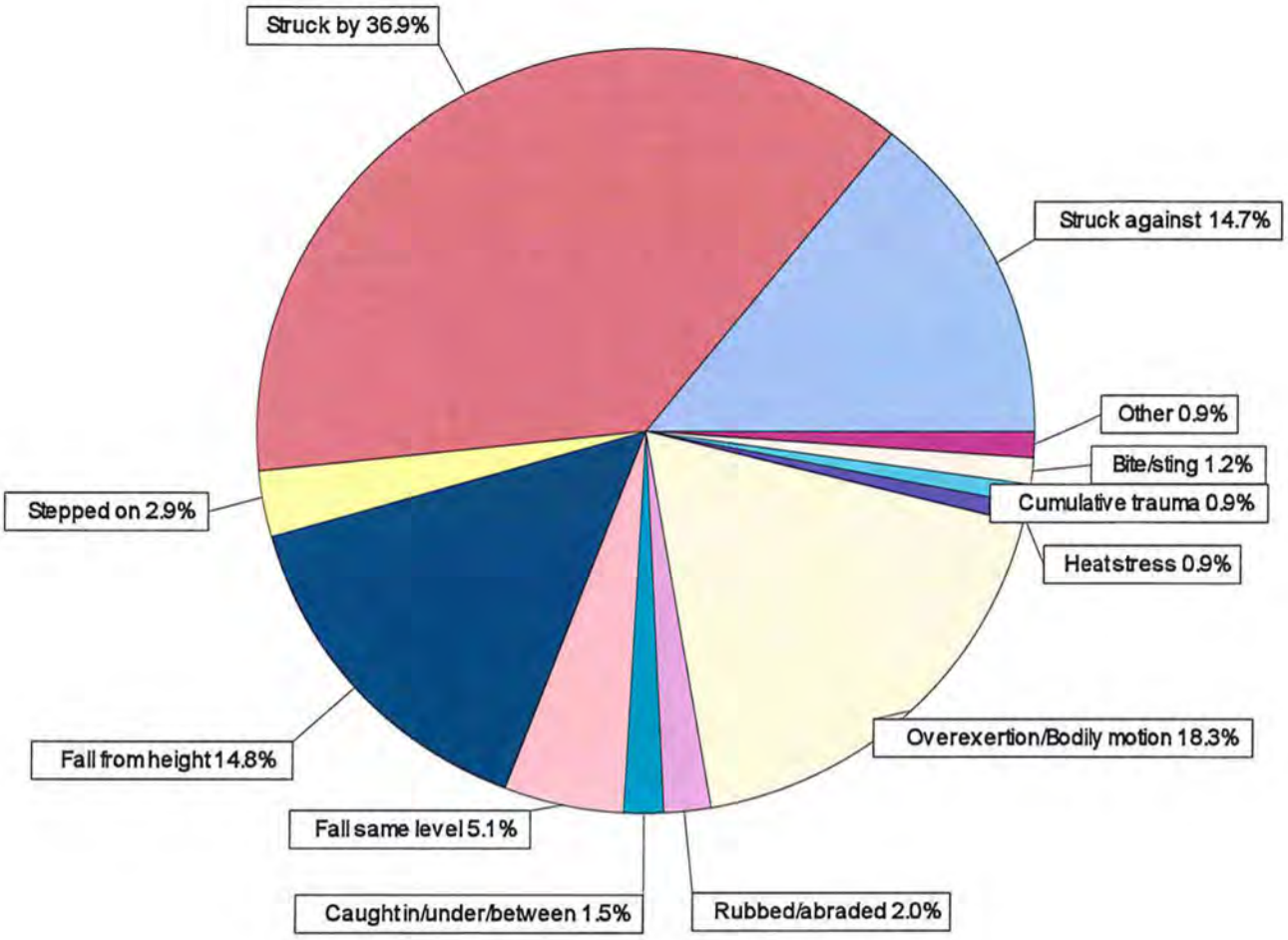
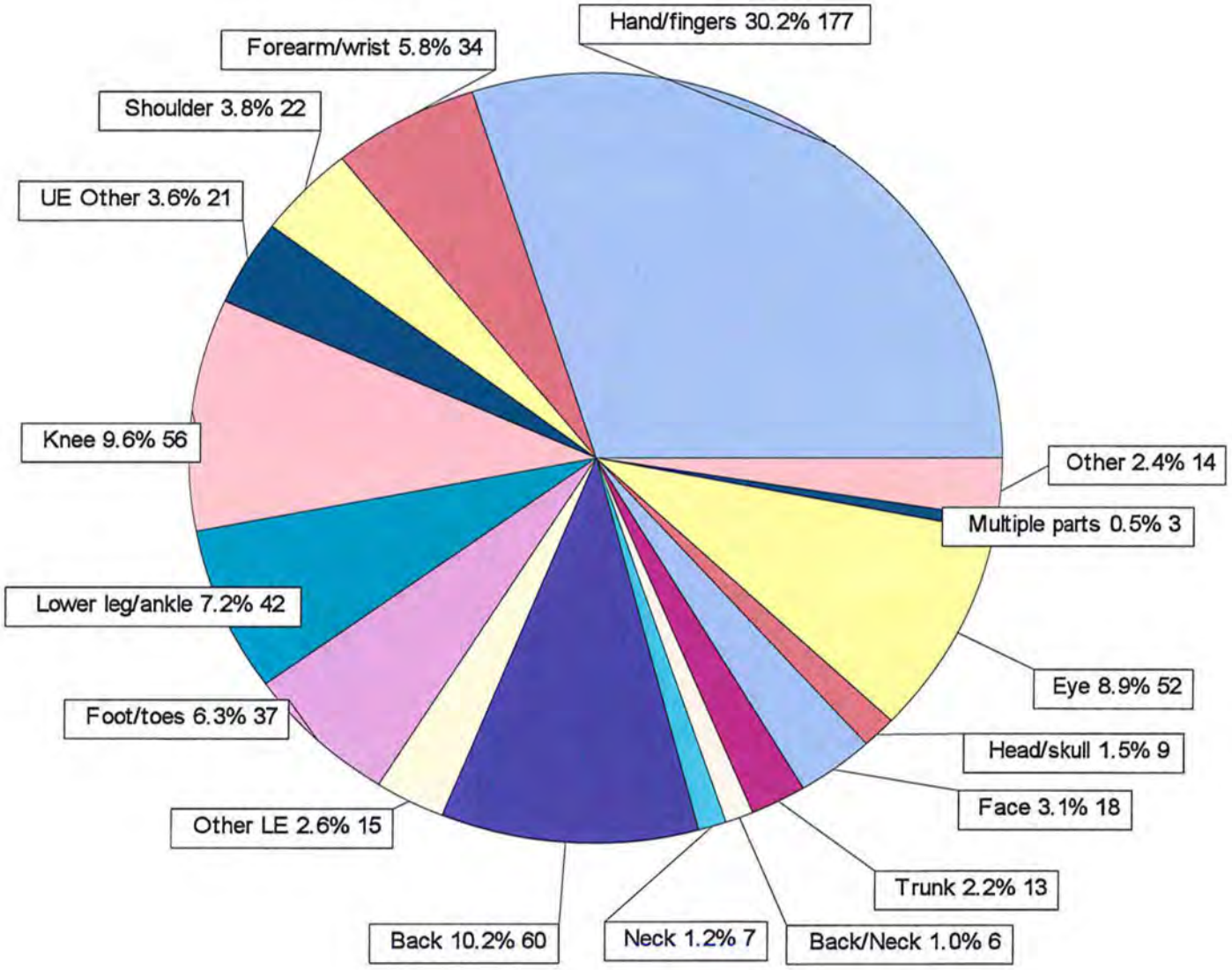


Figure C1:2 Body Parts Injured, Active Injury Surveillance Union Residential and Drywall Carpentry, 1999-2002



C2 Injuries from Pneumatic Nail Guns and Staplers

All nail gun and staple injuries were identified from responses to questions in the interview about tool use at time of injury. Text descriptions from the surveillance data were reviewed to confirm that the injury involved one of these tools. Injuries were described by the nature, body region and mechanism based on the report of the carpenter. The proportion of cases resulting in lost time, beyond the day of injury, was also calculated.

Text descriptions were used to identify more common patterns and circumstances of injury. A series of queries and cross-tabulations assisted in this process. Text descriptions and recommendations were reviewed and coded for additional concepts of interest including type of tool, type of nailing (flat surface, toenailing, through nailing), double fires, ricochets, projectile nails, and penetrations.

The sum of hours worked by the cohort during the 37 months was calculated; hours worked were stratified by union status. Crude and stratified injury rates were calculated per 200,000 hours worked (100 person-years of full-time work) limited to data from injured carpenters who participated in the interview. Confidence intervals were calculated as described by Haenszel et al., assuming a Poisson distribution (1962). All analyses were done through Microsoft ACCESS queries and export of data to SAS (SAS, 1999; Microsoft, 1997).

To supplement these data, a consecutive group of apprentices from the Carpenters Joint Apprenticeship Committee (CJAC) in St Louis were asked to complete a short questionnaire on their experiences with nail guns, injuries experienced and training.

Findings

Nail guns were involved in 80 (13.6%) injuries. The injuries are presented in Table C2:1 by nature of injury and body region involved. Over half involved puncture wounds to the hand or fingers. We had information on lost time from work for 75 of the nail gun related injuries; of these 52% (n=39) had lost time beyond the day of injury.

The mechanisms of these injuries are presented in Table C2:2. Seventy-six (95%) of the injuries were the result of the carpenter being struck; the single greatest cause of carpenters being struck, accounting for 23% of all struck by injuries. Of the 5 individuals with eye injuries, three were using no eye protection. Two were wearing safety glasses with side shields; one got debris over the top of his glasses as he worked overhead and the second had his glasses slide down his nose as he worked in the heat.

Although screw gun injuries were seen in drywall work, all nail gun injuries occurred in residential construction. To get a more accurate measure of risk, rates were calculated using only residential work hours (hours= 7,739,417). The overall rate of injuries associated with nail guns was 2.1 per 200,000 hours worked (95% CI, 1.7- 2.6). Injuries were more common among apprentices with 35% occurring in the first year of apprenticeship, 21% in the second year, 13% in the third year, and an additional 4% in the fourth year. The injury rate among apprentices was 3.7 per 200,000 hours worked (95% CI, 2.7-4.9) compared to a rate of 1.2 among journeymen (95% CI, 0.80-1.7). All injuries were among male carpenters.

The type of nailing activity, determined from the surveillance descriptions, are presented by type of triggering mechanism on the tool in Table C2:3. Injuries with both contact trip and sequential trigger tools occurred most frequently while through nailing.

In Table C2:4, factors contributing to the injuries are presented by type of triggering mechanism on the tool involved in the injury. It is of note that the categories are not mutually exclusive. Although based on small numbers, similar proportions of injuries involved use of the non-dominant hand, awkward postures, ricochets, penetration of the nailing surface, and lack of eye protection for both trigger types, while contact trip triggers were associated with more rapid, double fires. Ricochets occurred due to hitting knots in wood materials, metal truss components, other nails, and from dense laminated materials. Awkward postures often occurred while working in rafters or trusses. While not always the sole contributing factor, in 36 cases (68% of the injuries from guns with contact trips triggers and 45% of injuries overall) the injury would likely have been prevented by a sequential trigger.

Supplementary Survey from Apprentices

Questionnaires were received from 165 apprentices. Seventy-three percent (n=121) had been in the union for less than one year; 66% (n=109) had more than a year of carpentry experience and 16% (n=26) had more than five years experience. Training in the use of these tools is presented in Table C2:5 and ranged from being told "don't shoot yourself" to formal programs. The most common training was "hands on," followed by lectures, tool box talks or safety meetings, and video instruction. Forty carpenters (24%) reported that they had no training in tool use. We did not examine the relationship between training and injury since we had no information on time sequence.

Reports of the proportion of nail gun use by apprentices on residential sites are presented in Figure C2:1. On over half the sites, apprentices reported doing the majority of nailing with guns.

Fifty-four apprentices (33%) reported a work-related nail gun injury; 35 occurring in the last year. Nineteen individuals (11.5%) had experienced more than one injury. The patterns they reported were similar to those collected through the active surveillance. The apprentice was using the gun at the time of injury in 84% of the cases.

All injuries were associated with framing nailers and all occurred while framing or sheathing. Eleven injuries occurred while the apprentice was "bounce nailing". Thirty-five percent of the apprentices reported working for contractors who used sequential triggers; these triggers were used on the tools in only three cases when the carpenter was injured (6% of the injuries).

The circumstances surrounding these injuries were described in 51 cases and included 15 (29%) accidental misfires; three accidental contacts with the gun and 12 gun recoils resulting in double fire. In 19 cases (37%) there was penetration of the board being nailed due to splintering, deflection from a knot or another nail, or misplacement of the tool. In over half (53%; n=27) of the injuries there was a flying or airborne nail. As in the surveillance analyses, the categories are not mutually exclusive.

Discussion

Through these specific analyses the utility of active injury surveillance among a group of union carpenters is demonstrated. The combination of data elements allowed both the estimation of injury rates and examination of specific circumstances associated with each injury using information collected

from injured carpenters by their peers. The availability of the text descriptions allowed exploration of issues that had not been anticipated when the surveillance tool was designed.

Much of the previous literature on nail gun injuries comes from case reports or series in trauma journals (Bruno, 1998; Albericco, 1997; Kizer, 1995; Kenny, 1975; Wu, 1975). Puncture wounds to the hands and fingers are commonly reported, although there are reports of more serious, even fatal, injuries involving the face, eyes and vital organs (Webbe, 2001; Jithoo, 2001; Wang, 1999).

The information allowing identification of hours worked by apprentices and journeymen was very revealing. While the overall injury rate was identical to that reported by Baggs et al (2001), injury rates over three times higher among apprentices than among journeymen were documented, likely related to more hours of exposure as well as inexperience. Recognizing we did not capture all injuries among the cohort, our frequency and rate estimates are likely conservative. They are still higher than reported for construction workers in Ohio and North Carolina (Dement and Lipscomb, 2003). This is not surprising since rate calculations were for all trades involved in homebuilding in North Carolina and all union carpenters in Ohio; both groups included workers who did not use these tools and were not at risk, resulting in lower rates. More similar rates were observed when analyses were restricted to carpenters in North Carolina and residential construction in Ohio.

The majority of injuries involved puncture wounds to the hand or fingers, but should not be assumed to be insignificant injuries. Half of these men lost time from work and one injury resulted in a lengthy hospitalization for treatment of a wound infection.

Many of these injuries were felt to be related to the use of a contact trip trigger. While the triggering mechanism was not always the only contributing factor, in all likelihood the injury would not

have occurred with a sequential safety feature. As far back as 1987, recommendations were made to develop a triggering mechanism that would allow the discharge of only one nail, rather than rapid fire nailing (Nobel, 1987). While these tools are now available, they are not widely used.

Lastly, these data are from the perspective of carpenters -- both the injured workers and investigators -- with knowledge of their tasks and tools, but also the organizational structure under which they work. While some might view this as a limitation, we see this as a significant strength resulting in knowledge based, practical recommendations.

In addition to voluntary participation by injured workers, the surveillance program involved voluntary reporting of injuries by contractors, and ascertainment of injuries was not complete. Our recommendations are based on the universe of injures investigated and we cannot guarantee they are entirely representative. However, the overall injury rates are higher than reported by the Bureau of Labor Statistics (USDOL, Apr 2002) and the rates for nail gun injuries are very similar to those estimated by others (Baggs, 1999; Baggs, 2001; Dement, 2003) which is reassuring.

Data collection was limited to individuals who were injured providing no information on actual time spent using the tools or doing different types of nailing. Due to the manner in which our surveillance tool was designed, carpenters with repetitive motion complaints or sprains/strains were not asked what type of triggering mechanisms they had used – although few injuries of this nature were seen. Interviews were conducted shortly after the injuries occurred making it difficult to assess severity, particularly long term sequalae.

Implications for prevention of injuries from pneumatic nail guns

These data provide evidence that training, engineering modifications, and policy changes in the workplace and manufacturing arena are all appropriate targets for prevention of injuries associated with nail guns. One action, without attention to the others, will not address the variety of issues that appear to be involved. Regardless of whether the high injury rates among apprentices are related to more exposure to the tools or inexperience, these workers warrant targeted prevention efforts. The use of these tools cannot be assumed to be an unskilled task; training should not be limited to how to use and maintain the tools. Workers need to know how to safely position the tool and their bodies to prevent injury to themselves and co-workers. They should be aware of circumstances that are associated with inadvertent penetrations or ricochets including knots in wood, presence of other nails or metal truss components, and nailing into some of the newer, dense manufactured materials such as laminated beams and joists. As with any power tool, malfunctioning tools should be removed from service immediately. Training and workplace policy need to address the use of appropriate eye protection when using these tools (Lipscomb and Dement, 1999; Lipscomb, 2000).

The findings support the move to sequential triggers to decrease acute injury rates. Workers do not typically purchase these tools; the contractors who do, must be involved in this effort. Sequential triggers come on some, or can be installed on, new tools as well as being retrofitted on older tools, often at no cost. However, the sequential trigger is still not the industry standard. Leverage from workers' compensation insurance carriers could influence practice in the field and growing litigation from injured workers against the industry may force change (Charmas, 1996). Contact trip tools allow rapid fire "bounce nailing," a reason cited for their preference in this fast-paced industry. We are

unaware of any reports evaluating the accuracy of rapid fire nailing. If nails do not hit the target, construction quality suffers and unnecessary numbers of nails may be used, offsetting productivity gains from rapid fire contact trip tools. Contractors have also voiced concern over raising risks for repetitive trauma by requiring the use of sequential triggering tools and this issue should be evaluated. However, we saw few injuries of a cumulative nature compared to acute injuries making us question whether this fear is well-founded.

There are other areas where innovative engineering could help prevent injury regardless of the triggering mechanism. Design features of the nose piece could be improved. Because the tools discharge if any part of the nose piece is depressed, a worker can shoot over the intended surface. The use of a laser to clearly identify the target might improve placement of the nose contact. Creation of "aggressive" nose pieces have been described in trade journals (Arnold, 1999). To do this, the worker files the ends of the nose piece to create a rough contact that will grab materials and prevent slipping. This aggressive nose piece would be a hindrance in rapid sheathing activities, pointing to the utility, perhaps, of interchangeable nose pieces that could easily be changed.

From these data there appear to be some situations, or tasks, that are better suited for the use of a hammer and nails, for example, when the individual has to be in awkward positions where the heavy gun and trailing hose make proper placement difficult and may magnify hazards for falling. Nailing in trusses is such an example.

There are also situations where the use of a nail gun really helps; rapid, secure placement of a nail can prevent creeping of materials and the tools speed up productivity for sheathing, particularly. The majority of injuries in these carpenters were associated with through nailing tasks, such as nailing

studs or blocks, trusses or joists, as opposed to flat nailing used for sheathing activities. This provides some indication that contact trip tools might be safely used for flat nailing tasks such as sheathing or roofing. However, from an organizational standpoint, it is questionable whether tools would truly be designated for certain tasks based on the triggering mechanism; and there are dangers associated with contact trip tools, including carrying them with a finger on the trigger, that have nothing to do with specific nailing tasks.

Engineering changes and training programs should be developed and evaluated based on ongoing surveillance efforts. Both need to keep pace with materials development, such as the increasing use of very dense pre-manufactured beams which are more difficult to penetrate than wood. Carpenters in the field and the contractors, who hire them and are responsible for their safety, need to be involved in these processes.

Key Points

- Nail guns are responsible for an estimated 14% of injuries among residential carpenters.
- Nail guns are the single greatest cause of struck by injuries among residential carpenters, responsible for >20% of these injuries.
- Injury rates are over three times higher among apprentice carpenters than journeymen, likely due to greater exposure to these tools and inexperience.
- Over 65% of injuries associated with contact trip guns could likely be prevented by sequential triggers.
- Prevention should involve training, engineering and policy changes involving carpenters and contractors, and these efforts should be evaluated and informed by ongoing injury surveillance.

Table C2:1 Injuries associated with nail guns among union residential carpenters by nature of injury and body region, 1999-2002

	Nature of injury						
	Puncture wound	Fracture/ broken tooth	Contusion	Abrasion	Sprain/ Strain	Repetitive motion	**Total**
Body region							
Hand/fingers	46	4	2				**52** (65%)
Forearm/wrist	1				2		**3** (4%)
Foot/toes	9	3	1				**13** (16%)
Knee/thigh	3		1				**4** (5%)
Back		1			1		**2** (3%)
Eye	1			4			**4** (5%)
Face (tooth)		1					**1** (1%)
Total	**60** (75%)	**9** (11%)	**4** (5%)	**4** (5%)	**1** (1%)	**2** (3%)	**80** (100%)

Table C2:2 Mechanism of nail gun injuries among union residential carpenters, 1999-2002

Mechanism	Frequency (%)	Descriptions
Struck by/against	76 (95 %)	Hit by nail from tool (n=70;includes 1 eye injury) Hit by debris from nail (n=4; eye injuries) Hit by gun (n=2; tool recoil and dropped)
Fall from height	1 (1%)	Leaning over to nail gutter board from roof
Repetitive activity	2 (3%)	Developed carpal tunnel syndrome in dominant arm; carpenter attributed to use of framing nailer and associated awkward wrist postures. Forearm strain; attributed to use of tool overhead with difficult trigger safety mechanism.
Overexertion	1 (1%)	Strained back when picked up tool from ground.

Table C2:3 Type of nailing activity associated with nail gun injuries by triggering mechanism among union residential carpenters, 1999-2002

	Type of trigger mechanism[1]	
	Contact trip trigger (n=53) Frequency (%)	Sequential trigger (n=18) Frequency (%)
Activity		
Through nailing (nailing two pieces of wood together, such as joining 2x4's or blocks in framing)	32 (60%)	12 (67%)
Toe nailing (nailing at an angle, such as in corners)	5 (9%)	3 (17%)
Flat nailing (sheathing activities, such as flooring or roofing)	9 (17%)	1 (6%)
Not nailing [2]	2 (4%)	1 (6%)
Could not code based on information collected	5 (9%)	1 (6%)

1 Triggering mechanism unknown for 9 injuries; including injuries from fall, overexertion, repetitive motion (n=4)

2 Represent gun dropped from above and contact with nose piece of gun being carried/moved

Table C2:4 Factors contributing to nail gun injuries [1] among union residential carpenters by trigger mechanism of tool, 1999-2002

	Type of trigger mechanism [2]	
	Contact trip trigger (n=53)	Sequential trigger (n=18)
Contributing factor		
Use of non-dominant hand to handle tool	6 (11%)	2 (11%)
Placement of hand not holding tool/body (bracing materials, shooting towards self)	18 (33%)	9 (50%)
Awkward posture (work in rafters, leaning over, overhead, shooting back towards self)	8 (15%)	3 (17%)
Nail ricocheted (knot, laminated beams, metal truss components)	12 (23%)	6 (33%)
Rapid double fire, uncontrolled, misfire	17 (32%)	1 (6%)
Penetration of wood surface	11 (21%)	4 (22%)
Projectile nail	9 (17%)	0
By-passed safety mechanism	19 (36%)	0
Lack of eye protection	2 (4%)	1 (6%)

1 Categories are not mutually exclusive

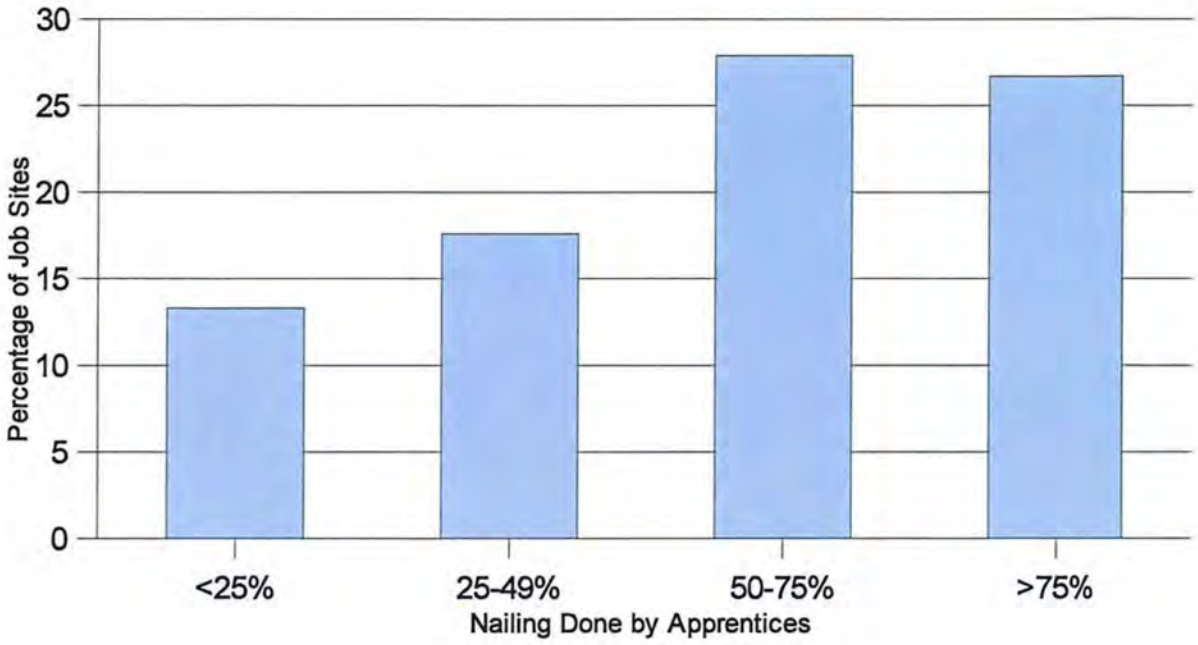
2 Triggering mechanism unknown for 9 injuries

Table C2:5 Nail gun training received by apprentices, carpenter apprentice survey

Type of Training [1]	Frequency	Percent
Read Pamphlet	15	9.1%
Lecture	52	31.5%
Tool Box Talk/Safety Meeting	28	17.0%
"Hands on" training	80	48.5%
Video	22	13.3%
Other (foreman explained, dad taught, tested on pamphlet, told "don't shoot yourself," company training and test)	10	6.1%
None	40	24.3%

[1] Categories are not mutually exclusive; some carpenters had training through more than one method.

Figure C2:1 Proportion of nailing with guns done by apprentices, apprentice survey



C3 Injuries from Falls

One hundred seventeen (117) falls were investigated. Investigated falls occurred at a rate of 2.5 per 200,000 carpenter hours worked. In Table C3:1, the frequencies and rates of falls are stratified by union status (journeyman vs. apprentice) and type (from height or same level). Individuals who fell had been in the union from less than a year to 32 years; mean time was 8.2 years for those who sustained falls from height and 10.9 years for same level falls. Sixty-two carpenters who fell from heights (71%) reported having had some type of fall protection training; 37 (43%) within the last year.

The injuries sustained in these falls are presented in Table C3:2 by nature of injury and body region. Injuries were most common to the lower extremities, for both falls from height and those from the same level, and most often involved contusions, sprain/strains or fractures. Data were available on lost time beyond the day of injury for 110 individuals. Seventy-three percent (n=60) and 71% (n=20) of those with falls from height and those with same level falls, respectively, had lost time from work.

Falls from the same level

In Table C3:3 factors that were identified as contributing to same level falls are presented. These are not mutually exclusive and more than one factor was often identified to be related to a given fall. In only 3 cases was the fall related to the worker tripping without another identified cause.

Two of these falls from the same height could easily have been falls from height resulting in more severe injury. One involved a carpenter who fell walking across trusses at the top plate of the wall and the other a carpenter who fell through joists catching himself on his arms, preventing his falling to the surface below.

Falls from height

Surfaces from which falls from height occurred are presented in Table C3:4. Falls occurred from a wide variety of elevated work surfaces the most common being the top plate of a framed wall or foundation walls, followed by scaffolds and ladders. Distances that the carpenters fell ranged from a foot to 25 feet (mean= 9.4 feet; median 9.0); 25 (28.7%) were from less than 6 feet and 62 (71.3%) were from 6 feet or greater. Only one individual reported using personal protective equipment (fall arrest) at the time of his fall. This man was wearing a harness and was tied off while working on a roof. The roof toe board broke off and he fell an estimated 12 feet before being caught by his harness. He sustained bruises on his arms and a cut on his face from the rope.

Factors identified as contributing to falls are presented in Table C3:5. The most common were ladder related including ladders used in ladder jacks (scaffolds), work surfaces that were not secure, scaffold related problems, speed and time pressures, and unprotected openings.

Site visits

Ninety-five (95; 81%) work site assessments were made. Site visits were conducted from the day of injury to 37 days afterwards (mean 7 days, median 6 days). Twenty-two percent were conducted within 3 days, 55% within a week, 77% in 10 days, and 90% within 2 weeks. All conditions were not observed, or even relevant, on every site; work was at different stages of construction and workers were sometimes not on the site when the visit was made resulting in different numbers of potential observations for each condition assessed.

Observations at these sites are summarized in Table C3:6 separately for falls from the same level, falls of less than six feet and falls of six feet or greater; the latter being the height at which the worker should be protected by fall protection regulations. Some conditions were never, or rarely, observed on these sites including use of safety nets, ladder cages and paint lines marking leading edge work. Others were almost universal including ground fault circuit protection and use of slide arresters on roofs. On sites where a fall from over six feet had occurred hard hats and eye protection were less likely to be worn by the majority of workers and housekeeping, materials storage and scaffolding were more likely to be described as poor or unacceptable.

Focus groups

When asked about dangerous tasks, working at height was the most feared risk described by apprentices, and walking the top plate was the most common exposure the apprentices talked about. Responses for apprentices at the time of the focus groups ranged from "terror to moderate comfort," but there was general acceptance that this was a task to be mastered to stay in the business. Fall protection taught in school did not necessarily follow to the work site; more seasoned workers did not practice the techniques they were taught in the apprenticeship program. Apprentices reported feeling powerless to make changes and they found they moved into accepting the practices of the journeymen and more experienced apprentices.

" I mean what they [apprenticehsip school] say is this is how it should be done.. But you just don't see it."

" Journeymen get a little careless. They get where they feel more comfortable, and they don't pay attention to what they are doing as much."

Journeymen reported that apprentices can practice working at height (walking a beam for example) but that they felt capable of being able to tell "whether an apprentice has it" and is going to be able to work at height in a few days. This was even the opinion of an experienced carpenter who had experienced bad fall several years earlier which he described as a "face dive into a concrete garage" resulting in serious injury.

A common theme on residential sites, reported by apprentices and journeymen, was "time is money – and there is not enough of either." Everyone seems to know how many hours have been allotted to finish a job, and when they are behind in their schedule. The perception seemed to be that in commercial construction there are both the time and money to "do things right" but that is not the case in residential building. Discrepancies between residential and commercial fall prevention activities were recognized by both apprentices and journeymen. Apprentices particularly, reported the fear of loss of their jobs if they could not work up to speed. This concern about time was reported to effect safety decisions. Apprentices reported that there should be more toe-boards used, that safety rails should be up, and that walk boards should be set up across joists but that it was just quicker to "walk on the stringers."

"Basically what I am saying is you watch films as an apprentice for safety being first and stuff like that. But if you want to fuss and whine about it, you can get out of there. They'll get somebody else."

"Fall protection in residential is don't get drunk the night before."

"If you are residential, fall protection is use your toe-boards and hope you land right."

While these themes were pervasive, there were exceptions.

"For me, I do not make enough to go up on a balance beam. You can do a lot from step ladders. I've walked the walls [top plate] and set trusses – that is fine; you have something to hold onto. But walking the walls when you don't need to is crazy."

"I've worked at a place, safety is, they preach safety, safety, safety. I mean there ain't no walking the top plate over there. The foreman even tells us " if you don't feel comfortable walking up there, you don't do it."

DISCUSSION

Summary

Falls accounted for 20% of injuries reported and investigated among these carpenters and falls were twice as common from heights as from the same level. Falls from height appeared, by diagnoses described at the time of the interview, to be more severe (more fractures, for example) but over 70% of both falls from height and those from the same level resulted in lost time beyond the day of injury. Apprentices had rates of falls from elevations that were 50% higher than journeyman, but falls from the same level occurred at similar rates for both groups. Over 60% of the carpenters who fell reported fall protection training. There was only one fall in which the carpenter was using personal protective equipment and this fall was arrested at 12 feet and resulted in minor injury.

Falls from the same level were most often related to weather, carrying objects - sometimes with view obstructed, housekeeping, terrain of the building lot, and speed of work. Falls from height occurred from a wide variety of work surfaces and often involved ladders, work on unsecured surfaces, scaffolding, and unprotected openings as well as speed and weather conditions. Sites on which falls from height had occurred were less likely to have workers using hard hats and eye

protection and more likely to have poor housekeeping and materials storage and unacceptable scaffolding - providing some indication that the overall safety climate may be poorer on these sites.

Some of these findings are quite consistent with reports of others. Cattledge, et al. (1996) reported 63% of non-fatal construction fall claimants in West Virginia had training in fall protection, but fall protection was not commonly used. Ladder and scaffold falls accounted for 50% of the falls and nearly 60% of falls occurred from heights below 10 feet. Half of the claimants were using tools or handling materials at the time of their fall. Fatal falls from FACE investigations (USDHHS, 2000) among carpenters bear striking similarity to circumstances identified in these investigations, documenting that the margin between injury and fatality can be small.

Limitations

In addition to voluntary participation by injured workers, the surveillance program involved voluntary reporting of injuries by contractors, and ascertainment of injuries was not complete. As such, these injury rates are conservative and the recommendations are based on the universe of injuries investigated. No information was available on severity of injury beyond the description given at the time of the injury which could be useful in targeting prevention, but is not essential in understanding the circumstances surrounding the falls and making prevention recommendations.

Data were only collected from injured workers and on sites where falls occurred. Thus, no exposure information was available on the cohort or the hours of exposure to any particular risk factor - - things that are difficult to achieve with any construction workforce. We also lacked information that would allow us to compare site conditions where there had been a fall with those where no falls

occurred which could have been revealing. Site visits were sometimes made after the site had changed considerably from the day of the fall. However, overall safety conditions could still be observed on these sites.

Strengths and Contributions

Despite the limitations, there were a number of strengths to this approach. Participation among injured carpenters was very high – likely due to the interviews being conducted by other carpenters with an understanding of the trade and the way work is done. These data are from the perspective of injured workers and experienced journeymen carpenter investigators which we believe is important in fully understanding the circumstances surrounding injuries and in improving prevention recommendations.

The interviews, and site visits, provided much more detail on circumstances surrounding falls among carpenters than typically available through other sources such as insurance records or the BLS summaries. As recommended by other scientists studying injury (Smith, 2001), we were able to take advantage of text information collected in detailed interviews and this descriptive information provided insight into causes of injury from falls and helped identify possible points of intervention. The focus groups added qualitative information about exposures, work organization and risk perception that provided important information about the context of the work of these carpenters.

As in the FACE program (Higgins et al, 2001) the investigation protocol was designed to collect information on the agent or source of energy transfer responsible for the injury, the worker, and the environment - including work organization issues. This approach, using a modification of

Haddon's matrix (Robertson, 1992) allowed the identification of multiple intervention points for any given injury -- and in this case from the perspective of injured workers and experienced journeymen investigators.

Conclusions

The very nature of the work done by these carpenters requires them to work at height. To accomplish this work they use ladders and scaffolds frequently, so it is not surprising that many injuries are associated with these types of equipment. Use of proper ladders of appropriate size for the job, setting them appropriately - staking and moving them frequently as required by the work are all important. Ladder jacks used for scaffolding are difficult to manage – carpenters recommend the use of pump jacks which are lighter to set up and easier to adjust to increasing height. In several cases the carpenter mentioned knowing he should not have used the top of an extension ladder or a folded step ladder but did so because they were available. Younger workers and more seasoned carpenters need fall protection training, and reinforcement of that training, that incorporates ladder and scaffold safety - this should include safe work practices as well as erection and dismantling. Workplace norms must be established that do not allow the inappropriate use of equipment.

Among these carpenters there were also many falls related to work surfaces that were not adequately secured or unprotected openings. It is easy for carpenters to create traps for themselves and co-workers as the structure is being raised. As one investigator noted "in this business, the surroundings change by the minute (JN)." Particularly as a house is being framed, hazards are being created as the building is being constructed; workers are constantly adding elements to the structure

that are not stable. It is important for workers to never leave a trap (an unsecured joist or window ledge, an open stairwell). .. for themselves or someone else. One investigator advised "don't get on it unless you built it or checked it out (JN)." This need for being ever vigilant while doing physically taxing work creates a significant challenge. It also speaks to the need to systematically build safely. Openings should be covered as routine procedure, for example.

Use of recognized fall protection strategies such as guardrails, toe boards, tying off to an appropriate anchor and covering openings were all identified by these carpenters as things that could have prevented their falls. However, these practices were not the norm on many sites where falls occurred. At times carpenters identified hindrances to use of some protective equipment including ropes restricting side to side movement, but often it was an issue of lack of standard work practices.

At many points in residential building the appropriate infrastructure is not in place to allow a secure anchor for tying off of personal fall arrest equipment. For example, a number of falls from height that were investigated involved work on the top plate of a framed wall. Working on the top plate is a common practice in residential building; however, the work often does not have to be done from there. Use of ladders around the perimeter can allow the same access without the same risk, as long as the appropriate equipment is used and the ladders are set properly. There are also circumstances where appropriate anchors would allow workers to routinely tie off -- siding and roofing, being two examples.

Weather conditions contributed to significant proportions of falls from the same level and falls from height. In this area of the country carpenters face cold, snow, rain, wind, and heat all which were felt to contribute to these falls. While it is impossible to modify the weather, there may be times that

behavior needs to be modified based on the weather. Site conditions need to be attended to as well including frequent housekeeping and grading as possible. Consideration needs to be given to use of gravel or sand to decrease problems related to mud, frost or snow.

It is clear that time pressures are significant in residential construction. While work needs to be done efficiently "safety and speed do not mix" particularly when work is being done at height. Even for same level falls, "on bad ground (which includes weather and rough terrain) the speed limit is lower. (JN)."

Team work and communication skills are essential in this work. Devastating falls can occur when the work crew does not know how to communicate to work together effectively as a team. These are skills that are not typically taught as carpenters learn their trade, but are essential to working safely.

Apprentices receive fall protection training as part of their school training yet they often go to work on sites where practices are not in place. While there might be some hope that they will use their training when they get to positions of greater responsibility and authority, there is some indicaiton from these data that, in fact they do not, being more likely to adapt the practices of more experienced carpenters with whom they work.

Work place norms that incorporate constant vigilance and preventive behaviors likely will only change through a combination of training and policy changes. On small residential sites this is challenging. Without question, there are things workers need to do to be responsible for their own behavior and safety -- but as with other public health efforts, changes that will influence more than one worker at a time are likely to be much more effective.

The union has role in providing training and establishing norms for how work at heights by their members is to be done. Contractors also bear responsibilities. Appropriate equipment must be available to their employees – and workers should not work without it. Time pressures were likely an issue in a number of these falls. Residential is fast paced work – but a serious fall can set a project back, and cost large amounts to the contractor in direct and indirect costs and result in huge personal costs to carpenter and his family.

Key Points:

- Falls accounted for 20% of injuries reported and investigated among these carpenters and falls were twice as common from heights as from the same level.
- There was only one fall in which the carpenter was using personal protective equipment and this fall was arrested at 12 feet and resulted in minor injury.
- Falls from the same level were most often related to weather, carrying objects - sometimes with view obstructed, housekeeping, terrain of the building lot, and speed of work.
- Falls from height occurred from a wide variety of work surfaces and often involved ladders, work on unsecured surfaces, scaffolding, and unprotected openings as well as speed and weather conditions.
- Sites on which falls from height had occurred were less likely to have workers using hard hats and eye protection and more likely to have poor housekeeping and materials storage and unacceptable scaffolding - providing some indication that the overall safety climate may be poorer on these sites.
- Use of proper ladders of appropriate size for the job, setting them appropriately - staking and moving them frequently as required by the work are all important.
- Ladder jacks used for scaffolding are difficult to manage – carpenters recommend the use of pump jacks which are lighter to set up and easier to adjust to increasing height.
- Apprentices had rates of falls from elevations that were 50% higher than journeyman, but falls from same level occurred at similar rates for both groups.
- In focus groups, apprentices reported work at height as their most feared risk involved in their work; fall prevention techniques taught in school, do not necessarily get applied on the work site.
- Younger workers and more seasoned carpenters need fall protection training, and reinforcement of that training, that incorporates ladder and scaffold safety - this should include safe work practices as well as erection and dismantling. Workplace norms must be established that do not allow the inappropriate use of equipment.
- Among these carpenters there were a number of falls related to work surfaces that were not adequately secured or unprotected openings.
- Working on the top plate of a framed wall is a common practice in residential building; when working on the top plate there is not typically anything to which the carpenter can tie off. However, the work often does not have to be done from there. Use of ladders around the perimeter can allow the same access without the same risk, as long as the appropriate equipment is used and the ladders are set properly.
- While work needs to be done efficiently "safety and speed do not mix" particularly when work is being done at height.
- Use of recognized fall protection strategies such as guardrails, toe boards, tying off to an appropriate anchor and covering openings were all identified by these carpenters as things that could have prevented their falls. However, these practices were not the norm on many sites where falls occurred.

Table C3:1 Falls in residential construction and drywall installation, union carpenters 1999-2002, by union status

Type of fall	Frequency (%)	Rate[1] (95% CI)	Rate ratio
Fall from same level			
Journeyman	20 (66.7%)	0.63 (0.30, 1.2)	1
Apprentice	10 (33.3%)	0.66 (0.40, 1.0)	1.1
Total	30 (100.0%)	0.64 (0.43, 0.92)	--
Fall from height			
Journeyman	49 (56.3%)	1.6 (1.2, 2.1)	1
Apprentice	38 (43.7%)	2.4 (1.7, 3.3)	1.5
Total	87 (100.0%)	1.9 (1.5, 2.4)	--

(1) Rates are per 200,000 hours worked

Table C3:2 Injuries sustained in falls by nature of injury and body region, union carpenters 1999-2002

	Head/face	Upper extremity	Trunk	Lower extremity	Multiple	**Total**
Falls from height						
Concussion	2					2 (2.3)
Contusion	1	8	9	8		26 (29.9)
Cut	2	3		3		8 (9.2)
Dislocation		2				2 (2.3)
Fracture	1	6	6	8	2	23 (26.4)
Sprain/strain		5	6	11	1	23 (26.4)
Multiple injuries				2	2	2 (2.3)
Chipped tooth	1					1 (1.1)
Total	**7**	**24**	**21**	**30**	**5**	**87** (100.0)
Falls same level						
Contusion		1	3	7		11 (36.7)
Cut		1				1 (3.3)
Fracture		4	1			5 (16.7)
Sprain/strain			1	11		12 (40.0)
Puncture			1			1 (3.3)
Total	--	**6**	**6**	**18**	–	**30** (100.0)

Table C3:3 Factors [1] contributing to same level falls (n=30), union carpenters 1999-2002

Contributing factor	Frequency (%)[2]
Weather; rain/mud/frost	11 (37%)
Carrying object/materials; weight of materials	9 (3%)
Housekeeping	8 (27%)
Terrain/grade of lot	7 (23%)
Speed of work	5 (17%)
Access/egress to structure	3 (10%)
Tripped/stumbled without identified cause	3 (10%)
View obstructed; walking backwards	3 (10%)
Fatigue	2 (7%)
Pulling on object/materials	2 (7%)
Work surface not secure	1 (3%)
Awkward work posture (caused by staging of work task that should have been done before duct work)	1 (3%)

(1) Factors are not mutually exclusive.

(2) Represents percentage of falls with which this factor was associated.

Table C3:4 Surfaces from which falls from height occurred, union carpenters, 1999-2002

Surface	Frequency (%)	Description of surfaces
Elevated work surface	33 (37.9%)	Top plate (7) Foundation wall/whaler board (7) Floor joists(7) Rafters/trusses (5) Sub-floor (4) Ceiling joists(1) Homemade walk board (1) Deck around tub (1)
Scaffold	19 (21.8%)	Platform scaffold (Perry/ Bakers) (6) Ladder jacks/pic boards (5) Horses/bench with pic boards (4) Drywall bench /horses (2) Scissors lift (1) Patent scaffold (1)
Ladder	14 (16.1%)	Extension ladder (6) Step ladder (5) Multi-task convertible (1) Wall brace/using as ladder (1) Job made ladder (1)
Roof	10 (11.5%)	
Through opening	7 (8.1%)	Stairwell opening (4) Landing (1) Sub-floor (1) 3rd floor window (1)
Down stairs	2 (2.3%)	
Other	2 (2.3%)	Pile of plywood (1) Slide for material (1)
Total	**87 (100.0%)**	

Table C3:5 Factors contributing to falls from height, union carpenters 1999-2002

Contributing factor [1]		Frequency (%) [2]
Ladder related [3]		21 (24%)
Ladder improperly set	9 (10%)	
Improper ladder	6 (7%)	
Needed ladder	3 (4%)	
Slipped on ladder rung, step	2 (2%)	
Ladder failed	1 (1%)	
Work surface not secure		20 (23%)
Scaffold related		19 (22%)
Failure	8 (9%)	
Drywall horse (stepped off, unstable, tipped)	6 (7%)	
Tipped	3 (3%)	
No rails	1 (1%)	
Fell off steps of lift	1 (1%)	
Speed/time pressures		14 (16%)
Unprotected opening (stairwell, window, fireplace, other)		13 (15%)
Weather Mud, rain, snow, wind		13 (15%)
Lack of fall protection		10 (12%)
Lack of safety training		7 (8%)
Heaviness of materials		5 (6%)
Communication		5 (6%)
Needed help		4 (5%)
Loss of balance (one heat-related)		2 (2%)
Carrying materials		2 (2%)
Timing of tasks foundation, backfill		2 (2%)

(table continued)

Table C3:5 (cont.)

Crane problems setting I-beam, trusses	2 (2%)
Fatigue	2 (2%)
Failure of fall protection toe boards- slid over, broke	2 (2%)
Co-workers' action	2 (2%)
Housekeeping	1 (1%)
Awkward posture	1 (1%)
Contact w electricity	1 (1%)

(1) Factors are not mutually exclusive.

(2) Represents percentage of falls with which this factor was associated.

(3) Includes ladder jacks supporting pic boards

Table C3:6 Site conditions observed by type of fall, union carpenters 1999-2002

Conditions Observed	Height of Fall (% observed; number of total observations)		
	Same level (22)	Less than 6 feet (19)	Over 6 feet (49)
Hard hats worn by majority	62% (21)	71% (17)	55% (49)
Eye protection worn by majority	62% (21)	50% (16)	48% (48)
Sequential triggers on nail guns	13% (15)	25% (8)	24% (38)
Tape area for crane swing around	0% (2)	0% (3)	0% (8)
Ground fault circuit interrupters (GFCI)	95% (20)	94% (17)	97% (46)
Unacceptable or poor conditions			
Housekeeping	9% (22)	26% (19)	41% (54)
Materials storage	10% (21)	5% (19)	18% (51)
Access/egress to structure	33% (22)	37% (18)	28% (54)
Backfill around foundation	5% (21)	18% (17)	9% (54)
Condition of extension cords	19% (21)	13% (15)	13% (46)
Saw guards (not present, sticking)	0% (17)	0% (7)	3% (37)
Scaffolding	29% (7)	13% (8)	67% (15)
Ladders	26% (19)	31% (13)	17% (41)
Fall Protection [1]			
Fall protection plan reported on site	85% (20)	66% (15)	71% (48)
Guardrails around openings	50% (16)	75% (12)	60% (48)
Slide arresters on roof	100% (7)	83% (6)	95% (21)
Paint line 6' from leading edge	0% (3)	0% (2)	15% (13)
Lifelines available	50% (2)	75% (4)	46% (13)
Lanyards available	67% (3)	67% (6)	53% (15)
Harnesses available	80% (5)	67% (6)	56% (16)
Handrails in place	69% (13)	77% (16)	67% (33)

[1] safety nets, ladder cages never observed

C4 Measuring Acute and Cumulative Biomechanical Stress among Carpenters with Back Injuries

Background

Over the last three decades several low back injury risk assessment tools have been developed to provide ergonomics practitioners the ability to evaluate the relative risk posed by manual materials handling (MMH) tasks. The Work Practices Guide for Manual Lifting (NIOSH, 1981) and the Revised NIOSH Lifting Equation (Waters et al, 1993,1994) are two well-established methods developed by the National Institute for Occupational Safety and Health (NIOSH). The Lumbar Motion Monitor (LMM) risk assessment model (Marras et al, 1993) and the Three-Dimensional Static Strength Prediction ProgramTM (3DSSPP) were developed by researchers at The Ohio State University and the University of Michigan, respectively. Based on our current understanding of the etiology of occupation-related low back disorders it is clear that each of these assessment tools addresses an important facet of the low back injury risk paradigm, but that none of these models individually are able to identify all high risk activities. This perspective is supported the recent research of Lavender et al (1999) that showed poor correlation between the estimates of low back disorder risk that were produced by these three tools when assessing a variety of MMH tasks. The goal of the current study was to incorporate the strengths of each of these existing assessment tools into one hybrid assessment methodology. To build the foundation for this hybrid model, an overview of each of these constituent models along with our perceptions of each model's strengths and limitations is presented.

NIOSH Model

The NIOSH models (NIOSH 1981, Waters et al, 1993) utilize static workplace configuration information to develop estimates of weights that can be safely lifted by a majority of the working population. The workplace variables considered in the Revised NIOSH Lifting Equation (Waters, 1993) include: vertical position of load, horizontal distance between the load and the spine, frequency of lifting, vertical travel distance of the load, asymmetric posture of torso, and coupling quality between the lifter and the object being lifted. These measures are then combined in a multiplicative model to arrive at an appropriate weight (called the Recommended Weight Limit, or RWL) that can be lifted safely by a majority of the working population. The ratio of the actual weight being lifted to this RWL is a value called the Lifting Index (LI). LI values greater than 1 are said to place some workers at increased risk, while values greater than 3 are said to be a potential problem for a majority of healthy industrial workers (Waters et al, 1994). There are a number of stated assumptions that should be considered when applying this assessment technique. Among these assumptions are that the workers perform only two-handed lifts, they work for no more than eight hours, they are not lifting or lowering objects faster than 75 cm per second, and they are lifting in a relatively unrestricted work environment.

Two recent studies report results that support the effectiveness of the NIOSH method in predicting low back pain but also note some of its limitations. In a study of 97 MMH jobs, Wang et al (1998) report a monotonically increasing relationship between the severity ratings of low-back discomfort and the NIOSH Lifting Index. Their results showed that for jobs with a severity rating of 0 (on a 0-5 point scale) the mean lifting index was 0.8 while for jobs with a mean severity rating of 5 the mean LI was 4.1 with intermediate points following the trend. Another significant result from this study

was that 42 of the 97 evaluated jobs had an RWL=0, a result that the authors attribute to having tasks wherein lifting frequencies and/or horizontal distances exceeded those allowed by the NIOSH modeling methodology. In another study (Waters et al, 1999), fifty jobs in four different industrial facilities, were evaluated and the authors report that the unadjusted prevalence odds ratio for reported low back pain were 1.14, 1.54 and 2.54 for lifting indices of 0-1, 1-2 and 2-3 respectively. Interestingly, they report an unadjusted prevalence odds ratio of 1.63 for jobs with a lifting index of >3, and note potential selection and survivor effects may have influenced the results of their analysis.

While the NIOSH method is straightforward in application and has great utility in many industrial environments the static representation of the workplace does not take into account some of the human performance issues that have been implicated in the low back injury process. Specifically, in performing a manual materials handling task, the three-dimensional postures, velocities and accelerations have been shown to play a role in the development of low back injuries (Marras et al, 1995). It should be noted that the NIOSH model does consider dynamics from physiological and psychophysical perspectives, but trunk motion plays a direct role in spine kinematics and biomechanical loading and therefore is a facet of risk that is not directly addressed in the NIOSH approach.

LMM Model

Marras et al (1993) developed a risk assessment methodology that considered the importance of the lifting dynamics in the development of a low back injury. A device called the Lumbar Motion Monitor (LMM) was developed to capture the instantaneous position, velocity, and acceleration of the lumbar spine in the three cardinal planes of human motion. Using this device in industrial environments,

trunk kinematic data was collected from workers performing 403 industrial jobs. Multiple logistic regression was used to form a relationship between historical injury data and task parameters including these trunk kinematic variables. Their results showed that five parameters were adequate to distinguish between high and low risk jobs: lift rate, maximum sagittal angle, average twisting velocity, maximum lateral velocity, and maximum moment (model odds ratio of 10.7). The results of their work is a low back injury risk assessment model that takes as inputs these five task variables and the output is a single value that describes the probability of high risk group membership (PHRGM) for that job.

As with the other models, the LMM assessment tool is believed to be able to identify some but not all of the high risk activities that may lead to low back injuries. The principle strength of this model is that it is based on the empirical relationship between outcome measures (injury and job turnover rates) with quantifiable job characteristics, including human performance-related variables. With this approach comes the ability to begin to consider the role that individual differences may play in the etiology of low back injury. While this model was able to overcome the static biomechanical modeling limitations of the NIOSH Lifting Guides, a limitation to the generalizabilty of this model is that it was developed using data collected from a sample of jobs where workers performed "repetitive jobs without job rotation". Since this was an empirical model, the specific job dataset that was used to develop the relationship between work characteristics and risk will have a great influence on the model output. Since non-repetitive jobs were not included in the dataset, certain characteristics of these types of jobs may not be represented in this model's predictions. Further, because of the special emphasis placed on the variables describing trunk dynamics that resulted from this sample of jobs, some high risk activities, such as lifting heavy loads in awkward, static postures will often escape identification.

Three-Dimensional Static Strength Prediction Program Model

In contrast with the LMM model, the Three-Dimensional Static Strength Prediction Program (3DSSPPTM) model developed by researchers at the University of Michigan is not based upon repetitive jobs. Instead, it is a comparison of MMH activity requirements with a human strength capacity database. The inputs to this model are the major joint angles and the direction and magnitude of the force exerted by the hands. Once this three-dimensional biomechanical model is developed, the three-dimensional moments about the L5/S1 joint and spine compression can be calculated. Further, the three-dimensional moments can be compared with the data from the human strength capacity database so that an estimation of the percentage of a population capable of exerting these moments can be generated.

Several studies have illustrated the importance of documenting the relationship between a person's strength capacity and the physical demands placed on them during work (Chaffin and Park, 1973; Chaffin, 1974). Chaffin (1974) illustrated a sharp increase in low-back pain incidence rates when the job demands required forces exceeding the workers' strength capacity. This author showed that jobs whose average lifting strength ratio (LSR- defined as the ratio of the heaviest weight lifted to the average strength of people asked to perform that lift) exceeded 1.0 had a job related low-back incidence rate (low back incidences/1000 man-weeks) of ~2.3. This is as compared to ~.75 and ~.65 for jobs whose average LSR was between 0-.5 and .5-1 respectively. Chaffin and Park (1973) performed a very similar analysis but used the strength capacity of a large/strong man in the denominator of the LSR, thus normalizing the data such that it would be very unlikely to encounter a job have lifting requirements with an LSR exceeding 1.0. Their results showed that for jobs with a LSR

between .8-1.0 the job related low-back incidence rate approached 4 while the incidence rates associated with lower LSRs were less than 2.

It is felt that the relative strength of the 3DSSPP approach is in its ability to assess risks associated with one time exertions, because it compares directly the required moments of the task with population strength data. Another strength of the model is its ability to estimate value of Probability of High Risk Group Membership that can be compared with established load limits to assess relative risk. The limitations of this approach are in its ability to quantify risk in jobs that are highly repetitive in nature but do not have torque or spine compression forces that approach human strength capabilities or spine compression load limits.

In summary, the NIOSH and LMM models appear to be well designed for the evaluation of consistent, repetitive MMH tasks and therefore can give insight into the long-term cumulative trauma risks but, to varying degrees, are felt to be somewhat limited in their ability to deal with the acute trauma risks. The 3DSSPPTM , on the other hand, appears to be better able to address acute trauma risks posed by one-time high stress activities but is limited in its ability to address cumulative trauma risk. It is not our intention to say that these assessment tools are not individually effective in identifying high risk activities, in many cases one or another of these models contain the perfect assessment methodology. It is simply our contention that in assessing jobs with highly variable biomechanical demands, multiple tools may be necessary to identify each of the subtasks that may pose a risk. The goal of the current project was to develop a hybrid biomechanical assessment methodology (called Continued Assessment of Back Stress [CABS]) that uses these aforementioned assessment tools and represents their evaluations in such a way that the time-weighted distributions of biomechanical stress are the point of

emphasis, rendering a more comprehensive assessment of risk that is necessary for jobs with highly variable MMH demands.

Methods

Subjects

Twenty-eight experienced construction workers were the subjects in this study. Fifteen of the workers were from framing/carpentry subcontractors, eight were from masonry subcontractors, and five subjects were from drywall subcontractors. To illustrate the process and output of this modeling methodology, data from our analysis of the framing subcontractors will be presented in this paper.

Equipment

The equipment needed to gather the data for the assessment tools included three portable VHS cameras, a computer-based video coding system (OCS ToolsTM,, Triangle Research Collaborative, Inc., Research Triangle Park, NC), telemetry-based Lumbar Motion Monitors (LMMs) (Chattecx Inc., Chattanooga TN), and various measurement devices to quantify the weights and dimensions of the items handled on the construction sites. The video cameras were used to capture all of the activities performed by the construction workers. The computer-based video coding system was used to quantify the time these workers spent doing various activities and consisted of two modules. The first module imprinted a time code (at a rate of thirty frames per second) onto the videotapes. The second module read this time code from the tape and wrote the time code to a computer ASCII file when prompted by the human coder. This coding process will be outlined in greater detail in the Video Data

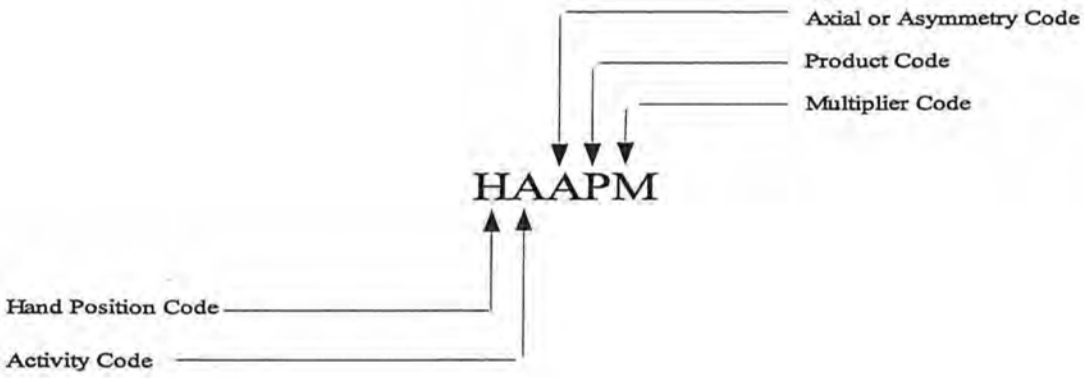
Processing/Modeling section below. The LMMs were used to capture the three-dimensional trunk motions required by the work activities performed.

Video Data Collection Procedures

Videotape footage of construction workers was gathered at 12 different home sites. All phases of the construction process were videotaped. In total, over 800 man-hours of videotape were collected. This included foundation work, framing of the house (floor joists/floor trusses, sub-flooring, building and raising walls, rafters/trusses, roof sheeting), drywall work, and veneer masonry. Each level of worker (crew leader, tradesman, material handler) were videotaped. Of these 800 man-hours approximately 350 were from the framing trade.

Video Data Processing/Modeling

The first step in processing the video data was to develop a task coding system that would document the body posture, the activity being performed, and the product being handled. The following five codes were used to create the overall "Task Code" for each MMH activity:



Hand Position Code. The Hand Position Code was used to define the degree of trunk flexion (from vertical) required by the task. Hand position was used as a surrogate for directly estimating trunk flexion because it proved to be more accurate and consistent to monitor a hand position while watching the videotape than to identify an angular back posture. This was especially true when the subject was either facing directly away or directly towards the camera. In this position, the amount of back flexion was not easy to discern, but the hand position was distinguishable and by assuming a relatively straight arm posture the trunk angle could be inferred. The two exceptions to this methodology occurred when the subject was kneeling on the ground or when the subject's trunk flexion was clearly not represented by the hand position (such as when the elbows were not straight or when the arms were not hanging vertically from the shoulder joints). In these relatively rare situations, the video analyst would define the hand position that coincided with the appropriate trunk angle. The five basic hand location codes were ground level, knee level, waist level, shoulder level, and overhead. These are described in more detail in Table C4:1 below.

Table C4:1 Description of Hand Location Code

Hand Code	Hand Location	Description	Height Range	Back Flexion
G	Ground	below midpoint of lower leg*	0-10"	>80°
K	Knee	between midpoint of lower leg and midpoint of thigh*	10-31"	30°-80°
W	Waist	between midpoint of torso and midpoint of thigh*	31-50"	0°-30°
S	Shoulder	between midpoint of torso and eye level*	50-65"	0°-10°
O	Overhead	above eye level*	>65"	-10°-10°

* Webb Associates (1978)

Activity Code. The Activity Code identified the MMH activity which was being performed. From this code, the direction of the hand force vector was determined. The 10 Activity Codes used in this study are described in Table C4:2. The first activity in Table C4:2, "Stand", was a code that was essentially classified as a "no-load" situation. Thus, activities such as standing and walking were all coded as "Stand." Two additional Activity Codes were used when observing the masonry subjects. The additional codes were "Bricklaying" and "Block Laying". Due to the speed at which the masons worked and the relative repetitive and predictable nature of the job, these codes covered all subtasks involved in laying bricks and block. This includes lifting the brick/block, loading of the trowel with mortar, buttering the head joint of the brick, furrowing (spreading) of the mortar bed joint, then laying the brick/block on the bed joint.

Table C4:2 Description of Activity Code and the subsequent hand force vector directions

Code	Activity	Description	Hand Force Direction
S	Stand	No load on low back	none
L	Lift/lower	Lift or lower object such that the hands chang height zones	vertical
F	Front hold	Holding or carrying object in front of the bod	vertical
C	Side carry	Holding or carrying object to the side of the body	vertical
P	Push	Horizontally pushing object away from the body	horizontal
T	Pull	Horizontally pulling object in towards the bod	horizontal
I	Pull up and in	Pull object upwards and inwards as in pulling long boards up from a lower level	upward and inward at 45o
O	Push up and out	Push object upwards and outwards as in pushing plywood sheets up from a lower leve	upward and outward at 45o
B	Bricklaying	Hands loaded with a brick, trowel, and morta	vertical
K	Block Laying	Hands loaded with a cylinder block, trowel, and mortar	vertical

Axial or Asymmetry Code. In order to correctly characterize the three-dimensional nature of the MMH activities, an optional Axial or Asymmetry Code was included in the Task Code. This code was only used if the task included some form of asymmetric or axial loading, otherwise it was left out of the Task Code. The two options for the Axial or Asymmetry Code were "A" and "Z." The "A" code was used when an object was held 30o-60o degrees from the midsagittal plane. The "Z" code was used for any activity which caused a torque about the spine in the transverse plane (i.e., caused a moment about the spinal column axis). Examples of activities which fell into this category include dragging long boards on the ground while holding the front ends to the side of the body or holding sheets of plywood to the side of the body and dragging them on edge across joists. For modeling of sliding activities, the coefficient of sliding friction was estimated to be .4 from a standard mechanics text (Beer and Johnston, 1988) and confirmed in lab testing.

Product Code and Multiplier Code. The materials or tools being handled were coded with a combination of the Product and the Multiplier Codes. The Product and Multiplier Codes were different for each trade group. Table C4:3 shows the codes used for the framing. Every material or tool had a code associated with it and for items that come in various sizes (such as long boards or sheets) a multiplier was assigned to it based on the size of the product being handled. For all boards, the standard length was 4', so if a worker was carrying three - eight foot lengths of 2 x 4, the product multiplier would be 6. The standard size for each sheet product was 2' x 4'. Therefore, a 4' x 8' sheet of plywood would have a product multiplier of 4 associated with it. The product multiplier for container-type items such as buckets or shovels were coded as either empty (multiplier code= 0) or loaded (multiplier code= 1). Since trusses and walls can come in a variety of shapes and weights, each

wall and truss was identified separately and its weight was estimated by summing the weights of the materials that made up the unit. Handling multiple items simultaneously was also permitted in this coding process.

Table C4:3 - Framer Product Codes

Product Type	Product Multiplier
0 - Nothing	N/A
1 - 2" x 10"	1 - per each 4' linear
4 - 2" x 4"	1 - per each 4' linear
6 - 2" x 6"	1 - per each 4' linear
8 - 2" x 8"	1 - per each 4' linear
L - LVL Beam	1 - per each 4' linear
O - OSB 7/16" Sheeting	1 - per each 2'x4' sec.
P - Plywood Decking	1 - per each 2'x4' sec.
C - Celotex Insulation	1 - per each 2'x4' sec.
G - Nail Gun	N/A
S - Skill Saw	N/A
R - Sledgehammer	N/A
K - Caulk gun	N/A
Z - Sawzall recip. saw	N/A
B - Black tar paper roll	N/A
A - Aluminum ladder	1 - per foot of height
T - Truss	A..Z describes each truss
W - Wall	A..Z describes each wall
N - Nails / bldg supplies	1- per each 10 lbs box
F - Fixed Objects (Rigid)	

The process of analyzing the video tapes consisted of viewing the tapes and then keying in the various Task Codes as the construction workers went about their work activities. Professional editing VCRs were vital to be able to slow down the video tapes in regions of time when the worker was changing postures/activities rapidly. When the analyst keyed the first character of the Task Code, the

video coding system program sampled the timecode from the videotape. When the analyst completed input of the Task Code and hit "Enter" the timecode and the Task Code was written to an ASCII file on the computer. The analyst would then continue to watch the video for changes in either the posture, hand load, or activity. When noted, he would enter in that Task Code and it, along with the appropriate time code, would be written to the computer file. This process would continue until the end of the region to be coded. A section of the ASCII file (along with the meaning of the code in parentheses) might look like this:

s t a r t	00:00:00.00	(start of coding session)
s _ _ _ _	00:00:00.00	(standing unladen)
g l _ g _	00:00:15.30	(lifting a nailgun from ground level)
w c _ g _	00:00:17.25	(standing with the nailgun at waist level off to the side of the body)
g l _ g _	00:00:25.00	(lowering the nailgun back to the ground)
g l a 4 4	00:00:26.35	(lifting 16 board-feet of 2x4s from the ground in an asymmetric posture)
s f _ 4 4	00:00:28.12	(holding 16 board-feet of 2x4s at shoulder level)
s _ _ _ _	00:00:35.11	(walking unladen)
k l _ p 4	00:00:51.00	(lifting a 4x8 sheet of plywood decking from knee level)
w c _ p 4	00:00:53.17	(carrying the sheet of plywood decking on the side of the body)
o f _ p 4	00:01:07.25	(handing the sheet of plywood decking to someone on second floor)
s _ _ _ _	00:01:09.45	(standing unladen)

Of the 350 man-hours of framing videotape footage a sampling procedure was employed that captured a representative sample of each level of worker (crew leader, carpenter, material handler) at each phase of the framing process (first floor joists, first floor flooring, first floor walls, second floor joists, second floor flooring, second floor walls, third floor joists, rafters (or roof trusses) and sheet materials for the roof). In total there were 67.5 man-hours of coded video tape for framers. The process of coding the videotapes took, on average, 3.5 hours per man-hour of videotape. It became

clear that it was not appropriate to assume that these datasets represented, in correct proportions, the amount of time spent in each of the activities during the construction of a home. A within-trade time weighting system was developed that involved getting estimates of proportion of time spent in each phase of the construction of the average house and then weighting our coded dataset to reflect these proportions.

Upon completion of this video analysis process, stick figure representations of these activities were created using the 3DSSPPTM system. Due to the importance of accurate postural data as noted by Chaffin and Erig (1991), subsequent laboratory simulations of the static postures were performed to increase the accuracy of the postural data input into the model. In total, there were 1181 Task Codes for framers. It was felt that it was unnecessary to develop a stick figure for each of these tasks codes because many were infrequent and/or were well represented by other more frequent activities. The following criteria were used for stick figure model development: if the Task Code contributed more that .1% of the total time or if the task represented an acute trauma risk (large moments, awkward postures, etc.) a model was developed for that Task Code. In total there were 487 stick figure models developed for framing and these accounted for 95.9% of the total work time of the framing trade. Figures C4:1 and C4:2 illustrate the process of representing the field activity with a stick figure and subsequent laboratory LMM simulation (to be described below). From the biomechanical analysis of the stick figure models, spine compression and the three-dimensional moments about the L5/S1 joint (x-axis: extension moment, y-axis: lateral bending moment, z-axis: twisting moment) were calculated from the 3DSSPPTM, as were the percent of the population capable of generating these moments. The final result of this static modeling were seven measures (spine compression, x-axis moment, y-axis

moment, z-axis moment, percent capable x-axis, percent capable y-axis, and percent capable z-axis) for each Task Code.

The stick figure representation was also used to document the spatial inputs required by the Revised NIOSH Lifting Equation. Consecutive Task Codes were used to establish the three-dimensional hand locations at start and end positions for each lift. The RWL was calculated at each of these positions and the task LI was calculated using the lesser of the two. The frequency of lifting was estimated by dividing the number of MMH activities in the period by the total time in the period. This generated a Lifting Index for each consecutive pair of Task Codes. See Figures C4:1 and C4:2.

Trunk Kinematics Data Collection Procedures

For safety and liability reasons, we were limited in our ability to take the LMM out to all of the construction sites. Our approach to gathering the required trunk motion data was to use the Task Codes from the video data analysis process to establish the start and end points for each of the MMH activities performed. Consecutive Task Codes were combined to form a ten character "Transition Code" which established the sequence of fundamental trunk motions performed by these workers. Using the above ASCII file as an example a brief segment of Transition Codes would look like this:

s _ _ _ _ g l _ g _	move from standing upright to bending over to ground level
g l _ g _w c _ g _	lifting a nailgun from ground level to waist level.
w c _ g _ g l _ g _	lowering the nailgun from waist level to ground level

In total, there were 6557 Transition Codes encountered in the data set, 2920 of which only occurred one, two or three times. Eight hundred and forty four of the more frequent Transition Codes

were simulated in the laboratory, accounting for about 87% of the total number of exertions in the dataset. The LMM simulations of these MMH tasks were performed by two male experimenters of approximately 50th percentile stature, who were extremely familiar with the construction tasks. Each of the MMH tasks represented by a given Transition Code was performed multiple times utilizing the different strategies that the on-site construction workers employed in getting from the starting point to the ending point of each MMH activity, in essence simulating the breadth of trunk motions represented by a single Transition code.

LMM Data Processing/Modeling

The three trunk motion parameters required for the Ohio State University LMM risk assessment model (peak sagittal angle, peak twisting velocity and average lateral velocity) were captured from each simulated lift. The other two required input variables, peak sagittal moment and the lifting frequency, were gathered from direct measurement during the laboratory simulations and on site, respectively. The average of the PHRGM values for all lifts within a Transition Code was then calculated. The output from this dynamic analysis was a single value of the PHRGM for each Transition Code.

Data Analysis

Basic Model Output. Our approach to representing these data was to develop histograms documenting the amount of time spent (or in the case of the LMM and NIOSH models, the number of lifts performed) at different levels of low back stress as predicted by the individual models. The method

used to develop the x-axis for these histograms was to identify the largest value encountered for each unbounded measure (largest LI encountered for the NIOSH model, largest encountered spine compression value, largest moment about the x-axis, etc.) or the high end of a bounded measure (100% probability of high risk group membership for the LMM model, 100% capable for the 3DSSPP model) and then divide the x-axis range into 10 equal size class intervals of the range of values (0-10%, 10-20% . . 90-100%). The y-axis values of these histograms were defined as the relative amount of time spent in each interval. These histograms were then used to help identify the specific activities (Task Codes and/or Transition Codes) that should be addressed in the intervention process. It was interpreted that activities that were located in the right-hand tail of the distributions for the spine compression or trunk moments or the left-hand tail of the percent capable measures placed the workers at risk for the more acute trauma type of injuries, while activities that were in the right-hand tail of the LI or Probability of High Risk Group Membership (PHRGM) placed the workers at risk for more cumulative trauma type injuries. In addition, activities that contributed large quantities of time to the peaks of the distributions of spine compression and trunk moments were also investigated for their potential influence on more cumulative trauma types of injuries. The individual high-risk activities that were identified by one or more of these procedures were then compared across assessment tools to illustrate the different points of emphasis of the constituent models, and to illustrate the benefit of the hybrid model approach.

Inter-Coder Consistency. The coding of the video tapes was a subjective process inasmuch as the coder had to estimate the hand height and object(s) being handled from the video footage with often less than ideal resolution and periodically obstructed views. It was felt that these videotape

characteristics could lead to differences in the codes keyed by different analysts. In order to assess the effect that this variability would have on the resulting histograms of biomechanical stress, a test of the consistency between coders was performed. One 30-minute section of videotape of a framer was coded by the four researchers responsible for video coding. The construction worker chosen as the subject for this inter-coder evaluation was a framer who performed various material handling as well as carpentry tasks. The section of videotape chosen was from the construction of the first floor walls after some of the interior walls had already been erected, hence slightly obscuring visibility. The video resolution was such that the height of the worker was approximately half of the height of the video screen. This situation was determined to be a realistic tape segment to test inter-coder consistency. The histograms of the moments about the x- y- and z- axes were developed and the variance of the times within each class interval rendered an estimate of the consistency across coders. The moment data were chosen for this analysis because of their sensitivity as compared to the more global variables (LI, PHRGM and compression) which tend to aggregate the data and thereby lose responsiveness to specific 3-dimensional moments.

Assessing Effects of Modeling Simplifications. The process of modeling the observed MMH activities involved making some simplifications in both the static and dynamic representations. In the static modeling, a "base model" was developed for each Task Code, but this model really represents a range of three-dimensional postures, including variable hand heights (within the bounds shown in Table 1), variable levels of asymmetry (defined by the categories of asymmetry code), and variable horizontal distances (within the observed reach envelope). Similarly, the Transition Code and the subsequent average PHRGM value present a "base model" representation of the dynamic activities. We felt that it

was important to quantify how well these base models represented the range of activities within a Task Code/Transition Code.

To investigate the effects of the simplifications in the static modeling, a total of 250 "alternate models" were constructed. These 250 alternate models were created by identifying five frequently occurring Task Codes within each hand height and then altering the three-dimensional hand positions. The five frequently occurring Task Codes within a hand height level included: two frequently-occurring sagittally-symmetric Task Codes, one sagitally-symmetric Task Code with a heavy object, one frequently-occurring 45o asymmetric Task Code, and one frequently-occurring side-carry Task Code. Of the ten variations from the base model, two had different hand heights (one higher, one lower), two had different moment arms of the load (one larger, one smaller), two had different angles of asymmetry in the transverse plane (one to the left, one to the right), and four variations with combined differences in hand height, moment arm, and asymmetry. The distance of the variation in the hand location in any direction was between 5cm and 13cm, depending on what was deemed realistic for that Task Code. The locations of these ten points formed a 3-dimensional volume around the hand location of the base model. To assess the impact of these simplifications on the assessment tools, the coefficient of variation of the NIOSH Lifting Index and spine compression was computed for each of these 25 base models.

A similar type of analysis was performed on the dynamic Transition Codes dataset to assess the effects of using the average of the multiple LMM simulations. As noted in the Trunk Kinematics Data Collection Procedures section, multiple repetitions of the LMM simulations were performed for a given Transition Code. Similar to the analysis of the static assessment tools the coefficient of variation of the

PHRGM measure was computed for each of the Transition Codes and is the measure used to assess the effects of representing all activities within a Transition Code by the group average.

Results

Basic Model Output

The main focus of this research was to develop a method to represent the biomechanical stresses of the low back in such a way as to aid in the identification of the high risk activities performed by construction workers. Figures C4:3-5 illustrate the basic output of this methodology. The time spent in the "stand" code (~50% of total time) has been eliminated from these histograms.

To illustrate the utility of this multiple assessment tool approach a list of four specific construction activities are presented in Table C4:4. In the first two cases presented in this table it is clear that one assessment tool has identified this as a very risky activity while the others do not. The third case is not quite so dramatic, but with spine compression exceeding 6600N and the NIOSH Lifting Index at 4.26 it was felt that spine compression highlighted the risk in a more dramatic way. To further emphasize the differences between the assessment tools, listed below are three MMH activities that were in the top five priority list for each of the assessment tools. Note the specific characteristics of these activities and how the different tools cue on certain aspects of the MMH activity.

Compression

1. Lifting 4 sheets of plywood from the ground.
2. Lifting 6 12' lengths of 2x4 from the ground
3. Lifting 3 12' lengths of 2x10 from the ground

NIOSH

1. Lifting one end of a large roof truss from waist to shoulder laterally (90o asymmetry)
2. Lifting a 2x10 from the ground in an asymmetric posture (45o asymmetry)
3. Lowering a 16' length of 2x10 from the shoulder to the ground in an asymmetric posture (45o asymmetry)

LMM

1. Lifting a nail gun from ground to waist laterally (90o -90o asymmetry)
2. Lifting a nail gun from ground to waist (45o - 90o asymmetry)
3. Lifting two 12' lengths of 2x4 from ground to side waist position (0o to 90o asymmetry)

The final entry in Table C4:4 illustrates the other important aspect of this modeling approach: the probabilistic representation of the time-weighted distributions of biomechanical stress. Reviewing the dataset, we were able to identify that working at ground level with either a nailgun, circular saw or no-load contributed to 51.9 percent of the productive time of these workers. The results of the risk assessments showed that none of the three assessment tools employed would characterize these three activities as high risk. In fact, the relative ranking of these particular tasks places them in the lower two-thirds of all tasks encountered in this study. However, knowledge of the literature with regard to the effects of flexed postures (McGill, 1997; Adams and Dolan, 1995), coupled with the our documentation of the large amount of time spent in these postures made this one of the priority areas for intervention in our work. Thus, not only does this technique provide insight into the high risk activities

found in the right-hand tail of the distributions shown in Figures 3-5, but also provides more detailed temporal information about tasks that are found in the more central regions of these distributions.

Table C4:4 Specific framer tasks identified as high risk by one or fewer assessment tools.

Activity	LMM Probability of High Risk Group Membership	NIOSH Lift Index	Spine Compression
Standing up to an upright neutral posture from using a nailgun at ground level in an asymmetric posture	72%	0.67	2625 N
Carrying a 12' length of 2x10 on right shoulder	12%	3.11	696 N
Lifting 4 sheets of plywood from ground level	51%	4.26	6600 N
a) Working with nailgun at ground level	37%	0.21	2424 N
b) Working with circular saw at ground level	41%	0.30	2251 N
c) Working with no hand held load at ground level	11%	0	2070 N

Inter-Coder Consistency

Figure C4:6 represents the distributions of moment about the x-axis that resulted from the video coding process by the four different coders responsible for coding all video in this study. The average, across the ten class intervals, of the standard deviation of the percent of time estimates for the four coders was 2.39% (range 6.8% - 0.35%) for the x-axis data and 1.05% (range 3.7% - 0.19%) for the y-axis data. None of the coders noted any postures that would generate a z-axis moment in this 30

minute segment. A more detailed review of the data revealed that the principle difference between coders was in the estimation of hand position and the estimation of hand load. See Figure C4:6.

Assessing Effects of Modeling Simplifications

The median coefficient of variation (CV) in the spine compression for the 25 codes analyzed was 11% while the median CV for the NIOSH Lifting Index was 19%. These figures are somewhat misleading however, because in many cases the mean value was quite low, which generated a high CV even with a small variance. In fact, the average of the absolute values of the difference between the base models and the alternate models was only 158 N in compression and only 0.08 in the NIOSH Lifting Index. The median coefficient of variation of the probability of high risk group membership values from the different activities which were described by a single Transition Code was 9%.

Discussion

Construction workers have exposure to a number of recognized occupational risk factors for back pain including strenuous work, manual materials handling, pushing, pulling, twisting, frequent lifting over 25 pounds, requirements for sudden unexpected maximal effort, and awkward postures (Bernold and Guler, 1993; Schneider and Susi, 1994). The material presented in this paper is the first phase of an intervention study undertaken to develop new tools and work practices to reduce loading on the low back during construction work activities.

Observation of construction workers in the home building industry revealed a wide range of work activities that resulted in highly variable biomechanical demands on the low back. It was realized

that these characteristics would make it difficult to employ standard low back stress assessment tools that have been developed for more traditional manufacturing environments and highlighted the need for a probabilistic representation of low back stress. This realization led to the development of the CABS methodology, an important tool in our efforts to prioritize tasks for ergonomic intervention.

We began this process with a group of nine dependent measures that were thought to assess risk from different perspectives. These nine were: spine compression, NIOSH Lifting Index, LMM PHRGM, x-axis moment, y-axis moment, z-axis moment, percent capable about the x-axis, percent capable about the y-axis, percent capable about the z-axis. As the process of using these indices to develop priority lists for ergonomics intervention proceeded, several of these measures were either found to be redundant with other measures or lacking sufficient sensitivity to distinguish between high and low risk construction activities. When the three-dimensional percent capable measures were evaluated almost all tasks had percent capable estimates of >99%, indicating that this tool did not have sufficient sensitivity for this application. Further, for those tasks that had percent capable levels lower that 99%, spine compression, NIOSH lifting index or both had already identified the task as high risk indicating a redundancy in these tools. Further analysis of the data revealed that three-dimensional moment data was redundant with the spine compression and the lifting index. In the end, a set of three measures (NIOSH lifting index, spine compression and LMM probability of high risk group membership) were found to identify the breadth of high risk activities encountered.

Table C4:4 contains a set of specific tasks chosen specifically to illustrate the importance of the CABS methodology (both the multiple assessment tool component and the probabilistic representation of stress) and points to differences in the theoretical underpinnings of the different assessment tools.

The OSU LMM model is clearly the most distinct of the three. Two of the five factors considered in this model are related to the dynamics of the task, one is related to posture and only two are related to the "static" configuration of the workplace (lift frequency and moment). Not surprisingly then, the LMM model placed many jobs that were dynamic (particularly those with complex three-dimensional dynamics) in the high risk category, while leaving many of the more static, high force tasks in a more low risk category. Examples of tasks identified by this tool include repetitive bending and twisting while securing subflooring materials to floor joists with nailgun, repetitive bending and twisting during veneer masonry work (getting mortar and brick from a stand and placing it in the wall), and repetitive bending and twisting during the cutting of the drywall materials. None of these tasks require a great deal of force, but instead create three-dimensional dynamic profiles that highlight the LMM model's particular sensitivities.

In contrast, the NIOSH Lifting Index and the spine compression estimates from the 3DSSPPTM were much more sensitive to the issues of external moment and trunk posture. Even with these fundamental similarities, however, there were still differences in their assessments that were worth noting. Specifically, the NIOSH equation is very sensitive to the three-dimensional location of a hand-held load while spine compression is more sensitive to the deviation of the center of mass of the torso from its neutral position. The two extremes of this spectrum would be 1) a person bending to the ground with little or no load in the hands (such as using a tape measure to mark off a wall location) and 2) a person holding a small weight in their hands at shoulder height with arms extended. In the first case the Lifting Index would be 0 while there would be a significant amount of spine compression due to the body mass and in the second case the Lifting Index could be very high and the spine compression

relatively modest. It is believed that the origin of these differences can be found in the differences between the pure biomechanical approach of the spine compression assessment and the contributions of the physiological and psychophysical aspects of lifting which played a role in the development of the NIOSH Lifting Equation.

The often dramatic differences between the measures of risk predicted by these models is consistent with findings of Lavender et al (1999). In their study five different low back injury risk assessment tools were used: the three considered in the current study and two variations of the United Auto Workers - General Motors Ergonomic Risk Factor Checklist. These authors studied 178 autoworkers from 93 production jobs in a metal fabrication plant. Their results showed poor correlations between the various measures of low back disorder risk. For the three assessment tools used in the current study their correlations were 0.54, 0.39 and 0.21 for LMM-NIOSH, LMM-3DSSPP, and NIOSH-3DSSPP, respectively. These authors go on to note that the differences between the assessment techniques may be the degree to which the tool is influenced by the individual behavior as opposed to the job factors (ie human performance issues vs. workplace configuration variables). In the current study we limited the influence that the individual behavior variables had on the data by developing relatively generic representations of the work activities. The differences between the models' assessments in the current study indicate that while individual performance differences are important, the differences in the theoretical underpinnings of these three tools create fundamentally different approaches to risk assessment.

In addition to the use of three different assessment tools, the other novel aspect of this research was the use of probabilistic representations of the biomechanical stress indices of these three

assessment tools. While the time weighted histograms that are the output from this approach can be used to identify the highly visible right-hand tail high risk activities, it can also help to identify the less prominent high risk activities in the central portion of these distributions. Specifically, there were several tasks that involved work at or near ground level that included little or no hand held load. The contribution of these jobs to the histograms came in the form of the peaks in the central regions of the distributions of the spine compression and moment about the x-axis. If we were to only prioritize for intervention based on a pure ordinal ranking of the biomechanical stress indices, these activities would not be set as priority items even though there is literature that highlights the risks in these postures (e.g. McGill, 1997; Adams and Dolan, 1995). Further, if these tasks were only infrequent and/or short duration activities we probably would not have considered them for intervention even though the literature says there is some need for concern. It is only when one tabulates the significant amount of time that construction workers spend in these postures that these activities move into the priority rankings. This illustrates that the time-weighted probabilistic representation of the biomechanical stresses gives an important insight into some of the activities performed by these workers that would have gone unnoticed with more traditional task analysis procedures.

Conclusions

Presented in this paper was a new methodology for quantifying low back stress. The strengths of this approach is that it utilizes several well-documented assessment tools and capitalizes on the strengths of each individual tool. The methodology also presents the data in such a manner that one gets an appreciation for distribution of stress throughout the workday, a characteristic that makes this

approach appealing for jobs that contain variable biomechanical demands. This technique has proved itself invaluable as we have begun the process of developing interventions for the construction industry because it has given us a more detailed description of risk associated with the various tasks performed by these workers.

Application of CABS Methods to Active Surveillance Data

As noted in the Specific Aims of this project, one goal was to create profiles of exposure to low back injury stressors for carpenters who experienced back injuries. This characterization was to be accomplished in two ways. First, using the CABS methodology to establish a description of the activity being performed at the time the low back pain was first sensed (the inciting event) to gain an appreciation for the acute trauma event, and second to use the CABS methodology to create a time-weighted historical exposure to gain an appreciation for the more cumulative exposures of these individuals.

While the quantification of the inciting event is limited to the specific biomechanical characterization of the activity being performed at the time of low back pain (spine compression, level of the Lifting Index of the activity being performed and level of the Probability of High Risk Group Membership of the activity being performed, etc.) characterizing the time weighted historical exposure is much more open-ended. Since the workers' exposures are described as distributions there are a number of potential candidates for variables that might lend important information to the description of the cumulative trauma potential. Figure C4:7 illustrates this point by showing a couple of values of spine compression at different percentiles of this generic distribution. In evaluating this distribution, one could argue that the 50^{th} percentile of this distribution is important because it shows the average exposure throughout the workday. It could be equally argued that it is the higher, less frequent loads that are leading to the cumulative deterioration of the tissues. Our approach in this work was to consider a number of these variables and quantify them for each of the assessment tools employed.

Methods

Job Specific CABS Histograms

Using the same basic approach outlined in the previous section, job specific histograms were created for the positions labeled "laborer", "carpenter", and "foreman". These histograms were developed using the same data sets that previously described. The difference is that in the data processing phase the specific work activities performed were partitioned in such a way that only those work activities performed by each of these worker classifications were included in the characterization of that worker's activities. What results from this analysis are nine histograms, one for each combination of worker type and assessment tool. The results of this effort is shown below in Figures C4:8-C4:16.

The next step in the process of evaluating this exposure data data was to fit a parameterized distribution to these histograms. This was accomplished by using the multivariate Johnson distribution fitting technique (Mirka et al, 2000) to best fit these histograms with a four parameter distribution from the Johnson family of distributions. This was necessary to facilitate the calculation of percentiles as will be described in the modeling section of this technical report. These distributions are shown in the lower graphs of Figures C4:8 - C4:16.

Work History Characterization

As part of the SLIPP surveillance interview for those with back injuries the work profile of each of the 51 subjects was provided. This data included the number of years that the individual was part of the union, the number of years in the apprenticeship program, the number of years functioning as a

journeyman carpenter, and the number of years that the individual served in a foreman/supervisory capacity.

Modeling

The theoretical construct underlining the modeling of this historical data is that by characterizing the cumulative and acute biomechanical stresses that occur before a low back injury/pain event occurs a deeper understanding may be generated. Therefore, the approach taken in the biomechanical modeling phase of this project was to generate a biomechanical representation of the activity that the individual is performing at the time of his injury, as well as a more cumulative assessment of the stresses that he accumulated during his work life as a carpenter. The approach taken to model the inciting event was simply to take a verbal description of the work activity being performed at the time of the injury from the surveillance interviews and to convert it into the 5 - 6 character of the CABS methodology. This code then represents a single value for the probability of high-risk group membership, lifting index, spine compression and the X-, Y- and Z moments about the spine.

The approach taken to model the cumulative exposure was to identify, for each of the nine CABS distributions the 50th, 75th, 90th, 95th, and 99th percentiles of these distributions. This was accomplished by using the best fit Johnson distribution and identifying that level of stress wherein the percent of the distribution to the left of that value corresponded to that percentile. Then, for each individual member of the cohort the number of years spent working in each of the three levels of the union system (apprentice, journeyman, foreman) were tabulated. Finally, to gain an appreciation for the

cumulative stresses the number of years spent working at each of these levels was multiplied by the stress levels for that particular task. For example:

Subject worked 2 years as an apprentice, 14 years as a journeyman carpenter and 3 years as a foreman before injuring his back. From the CABS distributions for spine compression we find that:

50^{th} %ile for the apprentice (laborer position) is 408 N

50^{th} %ile for the journeyman (carpenter position) is 748 N

50^{th} %ile for the foreman (foreman position) is 544 N

The cumulative exposure measure would be calculated as follows:

408N * 2 years + 748N * 14 years + 544N *3 years = 12920 Newton-years

This process was followed for each five different percentiles (50th, 75th, 90th, 95th, and 99^{th}), the three different jobs (apprentice, laborer and foreman), and the three different assessment tools (Lifting Index, Spine Compression, and Probability of High Risk Group Membership).

Results

Table C4:5 is a documentation of the inciting event data while Table C4:6 shows the results of the cumulative exposure modeling. The one line of missing data in Table C4:5 resulted from a verbal description of a task that had the individual lying on the ground and pushing a piece of sheeting into place with his feet. This task description was too far out of the standard modeling procedure for us to

be able to model this activity using CABS. The multiple blank lines in Table C4:6 are the result of incomplete survey data wherein the subjects left out critical data necessary to recreate their work history.

It should be noted that the data in Table C4:5 is by necessity often a rough approximation of the specific task codes used in the CABS modeling. Specifically, there were often times where the verbal description of the task was not an exact match with a specific code existing in the database that we had created in the original CABS project. For example, one of the acute events described the lifting of a cabinet. In the original project on which the CABS data is based we did not have anyone lifting cabinets. However, the description of the task was such that we could approximate the biomechanical loading using existing codes and hand held loads of similar magnitude.

In addition to the necessity of doing approximations on a number of the 51 inciting events there were some other noteworthy aspects of these verbal descriptions. Twenty eight out of 51 of the inciting events occurred with the individual's hands at ground (23) or knee (5) level. Eight of the events involved some type of unexpected loading (slips and falls, co-worker dropping their end of the load being lifted/carried, etc.). In addition to the more structured descriptions from the CABS methodology it is thought that these more qualitative aspects of the task might also add discriminative power to the analysis.

Limitations

The CABS methodology was developed using data from non-union residential carpenters in North Carolina. To apply the original data to estimate cumulative spinal stress for these union

carpenters, a number of assumptions or decisions had to be made. For example, based on information available on typical apprenticeship responsibilities, the framing laborers' loads were assigned to apprentices in their first two years. A more accurate assessment could have been made if video data were available to allow application of the CABS methodology specifically to union carpenters.

Table C4:5. Data Describing the Inciting Event

Subject	Inciting Event Data					
Subject	Compression	Sag Mom	Lat Mom	Twist Mom	Lift Index	PHRGM
R0008P	2839.8	181	0	0	2.7	57
R0014P	4664	364	1	0	9.9	85
R0016P	846.5	43	1	15	0.7	25
R0024P	569.5	17	131	0	10.5	13
R0028P	4593.7	267	0	0	5.5	51
R0030P	1727	109	0	0	0.8	23
R0041N	3331.7	194	0	0	2.8	51
R0074P	4593.7	267	0	0	5.5	51
R0089N	4593.7	267	0	0	5.5	51
R0098P	532.4	2	59	0	4.4	31
R0106P	512.5	12	1	0	0.9	59
R0117N	4664	364	1	0	9.9	85
R0118P	2273.5	134	3	0	0.4	55
R0132P	4473.8	253	0	0	7.7	85
R0146P	532.4	2	59	0	4.4	31
R0150P	4263.2	240	0	0	5.6	85
R0154P	3144.6	158	89	0	3.3	63
R0167N	660.7	22	20	0	1.4	43
R0172P	1381.9	88	107	56	4.7	13
R0198P	649.1	12	0	0	0.0	21
R0205N	2624.5	138	54	0	1.2	72
R0252P	569.5	10	58	0	4.8	13
R0270P	734.3	17	0	0	2.2	13
R0286P	2440.5	138	3	0	1.0	63
R0294P	644	4	85	0	7.6	31
R0304P	4664	364	1	0	9.9	85
R0305N	2977.5	172	0	0	2.5	85
R0319N	644	4	85	0	7.6	31
R0320P	3087.3	207	1	0	5.2	57
R0342P	4664	364	1	0	9.9	85
R0348P	2069.7	121	0	0	0.0	64
R0349N						
R0377N	1290.9	33	0	0	7.5	13
R0379N	569.5	17	131	0	10.5	13
R0383N	1954.9	116	0	0	5.0	23
R0389N	881.8	38	0	0	1.7	13
R0414P	2069.7	121	0	0	0.0	64
R0464P	4074.8	235	0	0	6.4	85
R0503N	644	4	85	0	7.6	31
R0526P	569.5	17	131	0	10.5	13
R0548P	794.4	36	17	50	6.4	56
R0562P	379.3	4	0	0	3.4	13
R0589N	4593.7	267	0	0	5.5	51
R0600P	4473.8	253	0	0	7.7	85

Subject	Inciting Event Data					
Subject	Compression	Sag Mom	Lat Mom	Twist Mom	Lift Index	PHRGM
R0601N	733.7	13	0	0	2.7	31
R0613N	346.1	3	9	0	1.1	67
R0636P	695.5	35	8	40	0.0	30
R0640P	4482.6	320	0	0	6.3	18
R0654P	2511	132	0	0	6.6	13
R0658P	3250.7	226	0	0	3.7	57
R0740P	4473.8	258	0	0	7.9	85
R0809N	644	4	85	0	7.6	31
R0827N	4664	364	1	0	9.9	85
R0799N	4473.8	258	0	0	7.9	31
R0719N	4074.8	235	0	0	6.4	85

Table C4:6. Data Describing the Historical Exposure

Subject Information				Cumulative Exposure Measures															
				PHRGM					Compression						Lifting Index				
Subject	Lab-Years	Fr-Years	For-Years	50th %ile	75th %ile	90th %ile	95th %ile	99th %ile	50th %ile	75th %ile	90th %ile	95th %ile	99th %ile	50th %ile	75th %ile	90th %ile	95th %ile	99th %ile
R0008P	1.9	0	0	60.8	98.8	125.4	133.0	138.7	775	1809	3747	5168	7752	2.0	4.9	8.9	10.4	12.1
R0014P	2	4.08	2.72	439.4	529.7	586.2	603.8	624.7	5348	13649	22070	25601	29893	4.2	13.5	29.0	37.4	51.1
R0016P	0	12.2	10	1223.2	1388.6	1485.2	1517.4	1569.6	14566	38039	59024	65742	70951	7.1	28.0	66.7	89.5	126.1
R0024P	0	0.07	0.03	5.5	6.3	6.7	6.8	7.0	69	175	268	297	320	0.0	0.1	0.3	0.4	0.6
R0028P	0	3.4	0	190.4	214.2	224.4	227.8	231.2	2543	6242	9248	10173	10866	0.9	3.1	6.6	9.7	18.1
R0030P	2	1.61	0.69	191.4	248.2	285.2	296.2	306.5	2396	5939	10106	12275	15511	2.8	7.8	15.5	19.3	25.5
R0041N				0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
R0074P	0.1	0	0	3.2	5.2	6.6	7.0	7.3	41	95	197	272	408	0.1	0.3	0.5	0.5	0.6
R0089N	0.4	0	0	12.8	20.8	26.4	28.0	29.2	163	381	789	1088	1632	0.4	1.0	1.9	2.2	2.5
R0098P	0.5	0	0	16.0	26.0	33.0	35.0	36.5	204	476	986	1360	2040	0.5	1.3	2.3	2.7	3.2
R0106P	0	24.9	10	1934.4	2188.7	2323.4	2368.3	2433.2	24065	61356	93568	103741	111540	10.4	39.6	91.5	125.8	193.8
R0117N	0	13.84	3.46	961.9	1086.4	1148.7	1169.5	1197.2	12235	30822	46585	51526	55291	4.9	18.4	41.8	58.5	94.9
R0118P	0.8	36.3	0	2058.4	2328.5	2448.6	2488.1	2526.8	27479	67408	100314	110786	119279	10.3	35.1	74.5	108.2	198.6
R0132P	2	13.41	1.49	895.4	1041.2	1118.4	1142.8	1168.1	11657	28855	44269	49919	55780	6.1	19.9	41.9	57.4	93.3
R0146P	1.2	1.2	0	105.6	138.0	158.4	164.4	169.2	1387	3346	5630	6854	8731	1.6	4.2	8.0	10.0	14.0
R0150P	2	1	0	120.0	167.0	198.0	207.0	214.0	1564	3740	6664	8432	11356	2.3	6.1	11.3	13.8	18.1
R0154P																		
R0167N	2	0.3	0	80.8	122.9	151.8	160.1	166.4	1040	2455	4760	6338	9119	2.2	5.5	9.9	11.8	14.3
R0172P	2	1.3	0	136.8	185.9	217.8	227.1	234.4	1788	4291	7480	9330	12315	2.4	6.4	11.9	14.6	19.7
R0198P	2	4.05	0.45	315.1	387.1	429.9	442.9	454.7	4090	10044	16123	18873	22542	3.3	9.6	19.2	25.0	37.1
R0205N	2	1.5	0	148.0	198.5	231.0	240.5	248.0	1938	4658	8024	9928	12954	2.5	6.6	12.3	15.2	20.7
R0252P	1.2	0	0	38.4	62.4	79.2	84.0	87.6	490	1142	2366	3264	4896	1.2	3.1	5.6	6.6	7.6
R0270P	2	13.9	0	842.4	979.7	1049.4	1071.3	1091.2	11213	27424	41752	47029	52584	5.7	17.8	36.5	50.7	86.8
R0286P																		
R0294P																		
R0304P																		
R0305N	0	1.15	3.45	250.7	286.4	310.5	318.6	333.5	2737	7507	12043	13529	14702	1.6	6.9	17.0	22.1	27.2
R0319N	0	2.72	0.68	189.0	213.5	225.8	229.8	235.3	2404	6057	9156	10127	10866	1.0	3.6	8.2	11.5	18.7
R0320P	1.8	4	10	821.6	965.6	1062.8	1094.0	1143.4	9166	24698	40270	46104	52088	6.8	25.2	59.1	75.9	93.9
R0342P	0	0.8	7.2	433.6	496.8	542.4	557.6	587.2	4515	12730	20781	23446	25568	3.0	12.9	32.4	41.6	48.3
R0348P	2	10	10	1164.0	1354.0	1472.0	1510.0	1566.0	13736	35904	56984	64600	72080	8.6	31.2	71.8	94.1	127.1
R0349N	2	0.2	0	75.2	116.6	145.2	153.4	159.6	966	2271	4488	6038	8799	2.1	5.4	9.8	11.5	13.8

Subject Information					Cumulative Exposure Measures PHRGM					Compression					Lifting Index				
Subject	Lab-Years	Fr-Years	For-Years		50th %ile	75th %ile	90th %ile	95th %ile	99th %ile	50th %ile	75th %ile	90th %ile	95th %ile	99th %ile	50th %ile	75th %ile	90th %ile	95th %ile	
R0377N																			
R0379N																			
R0383N																			
R0389N																			
R0414P	2	4.1	0		293.6	362.3	402.6	414.7	424.8	3883	9432	15096	17707	21264	3.1	8.9	17.4	22.6	34.6
R0464P	2	3.04	0.76		275.3	342.6	384.3	396.9	409.0	3503	8674	14177	16758	20305	3.2	9.3	18.5	23.8	33.6
R0503N																			
R0526P																			
R0548P	0	20	10		1660.0	1880.0	2000.0	2040.0	2100.0	20400	52360	80240	89080	95880	9.1	35.1	81.9	111.8	167.7
R0562P	0	18	2		1116.0	1258.0	1324.0	1346.0	1372.0	14552	36176	54128	59704	63920	5.5	19.8	43.7	62.4	108.2
R0589N	0	1	0		56.0	63.0	66.0	67.0	68.0	748	1836	2720	2992	3196	0.3	0.9	2.0	2.9	5.3
R0600P																			
R0601N																			
R0613N																			
R0636P	2	1.65	1.65		245.5	310.3	353.1	366.1	380.3	2948	7514	12696	15201	18707	3.2	9.5	19.7	24.6	31.6
R0640P	2	3.68	0.92		319.8	392.9	437.4	451.0	464.3	4069	10099	16331	19141	22862	3.4	10.1	20.5	26.5	38.0
R0654P	0	8.4	10		1010.4	1149.2	1234.4	1262.8	1311.2	11723	31062	48688	54373	58806	6.1	24.5	59.3	78.6	105.9
R0658P	2	4.4	10		850.4	1001.2	1102.4	1134.8	1185.2	9547	25622	41752	47845	54182	7.1	26.1	60.8	78.1	97.3
R0740P	2	5.7	10		923.2	1083.1	1188.2	1221.9	1273.6	10520	28009	45288	51734	58337	7.5	27.3	63.4	81.8	104.2
R0809N	2	6.5	6.5		779.0	916.5	1003.0	1030.5	1069.0	9214	24004	38420	43894	49708	6.3	22.1	49.9	65.0	87.1
R0827N	2	0.2	0.8		118.4	166.2	199.6	209.4	218.8	1401	3522	6555	8378	11356	2.4	6.7	13.2	15.9	18.7

Figure C4:1 Three phases of task modeling: 1) video capture, 2) stick figure representation for the 3DSSPP™ and NIOSH models, and 3) laboratory LMM simulations.
(Sawing at ground level (g f _ s _))

Figure C4:2 Three phases of task modeling: 1) video capture, 2) stick figure representation for the 3DSSPP™ and NIOSH models, and 3) laboratory LMM simulations.
(Carrying a 2 x 10 on shoulder (s c _ 1 3))

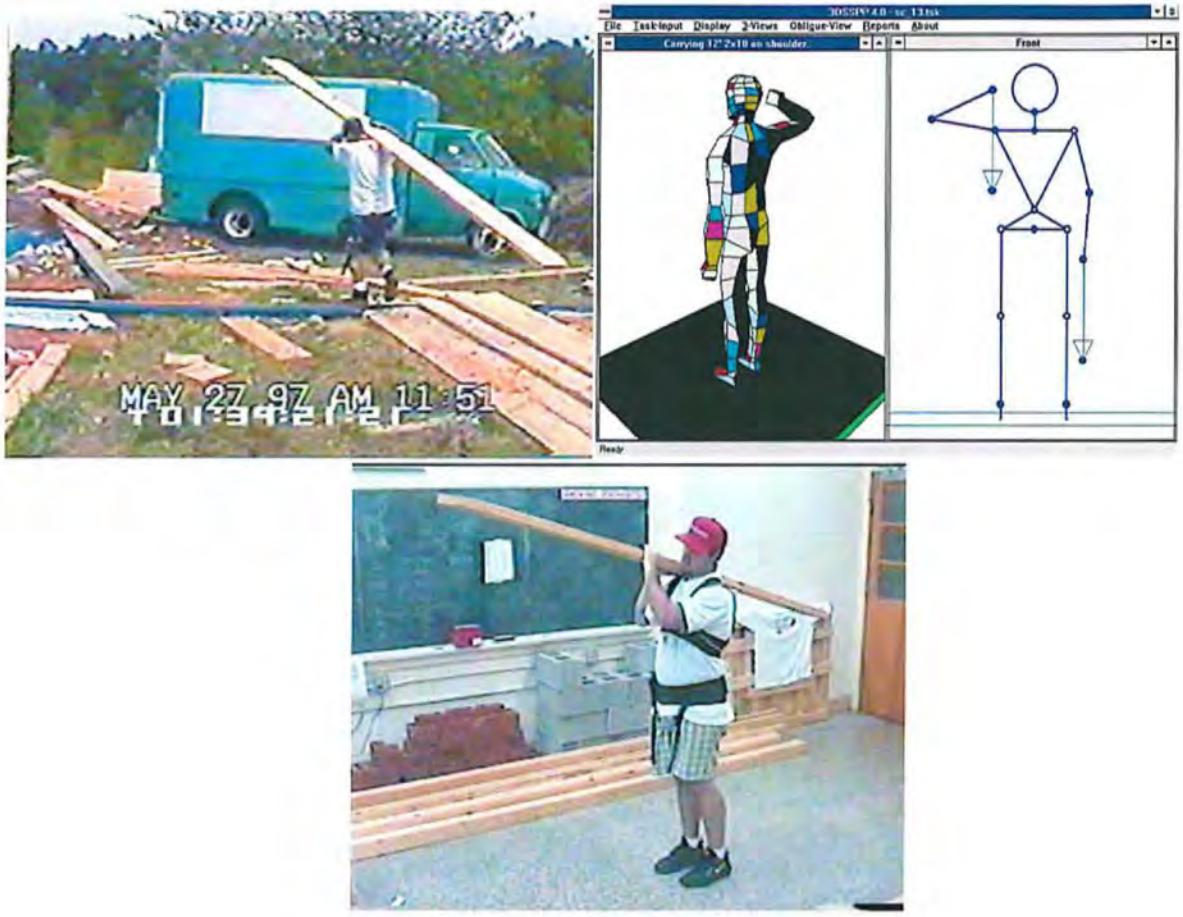


Figure C4:3 Distribution of spine compression values for framers.

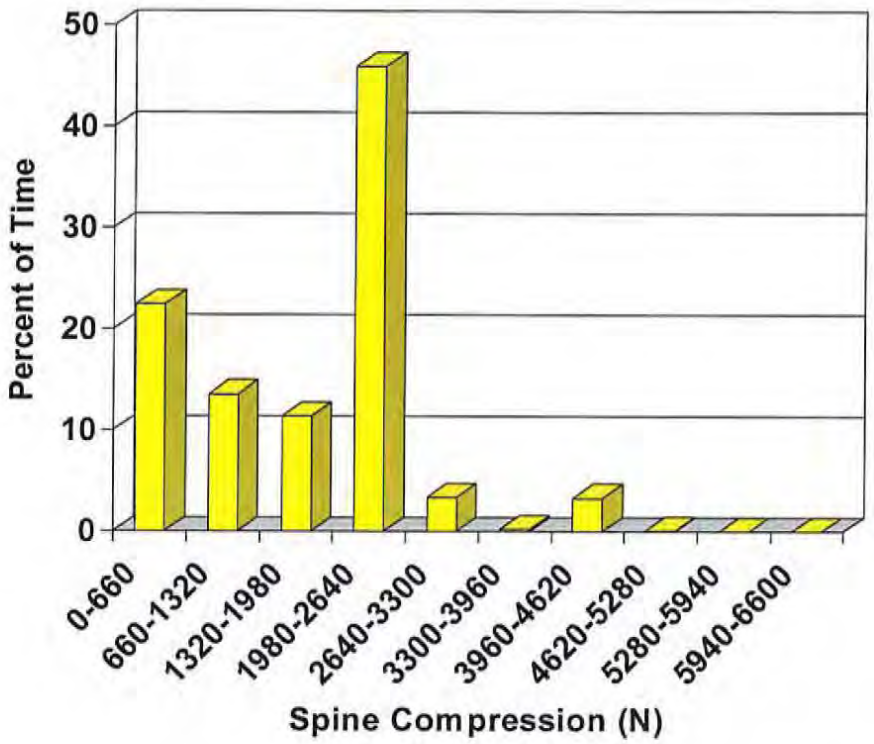


Figure C4:4 Distribution of NIOSH Lifting Index values for framers.

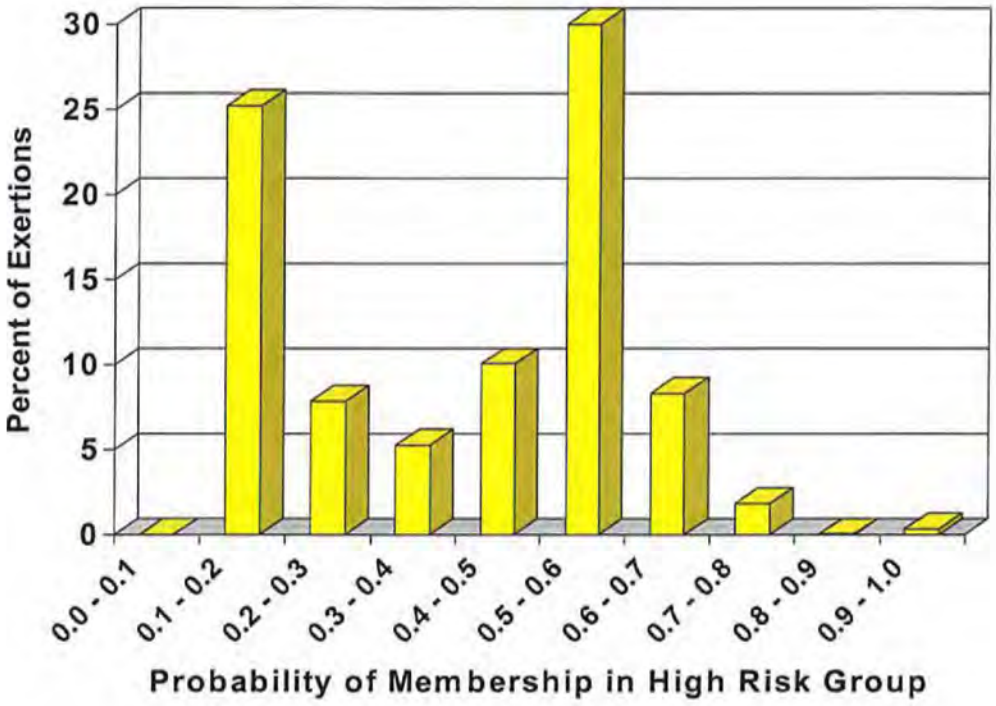


Figure C4:5 Distribution of probability of high risk group membership values for framers.

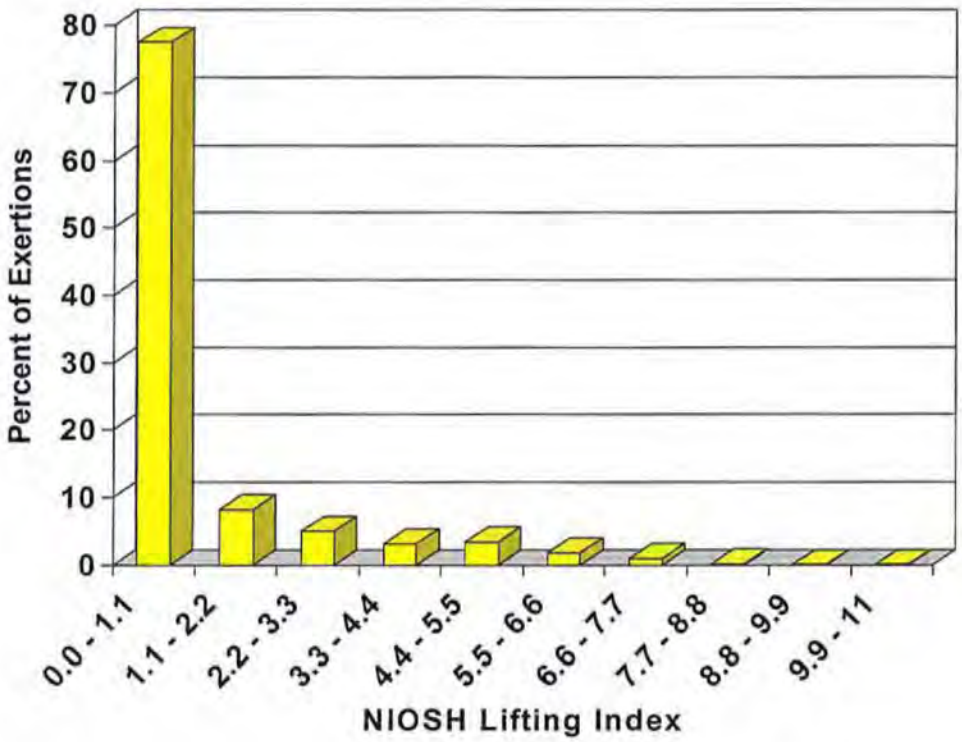


Figure C4:6 Distributions of x-axis moment as a function of coder to document level of inter-coder consistency.

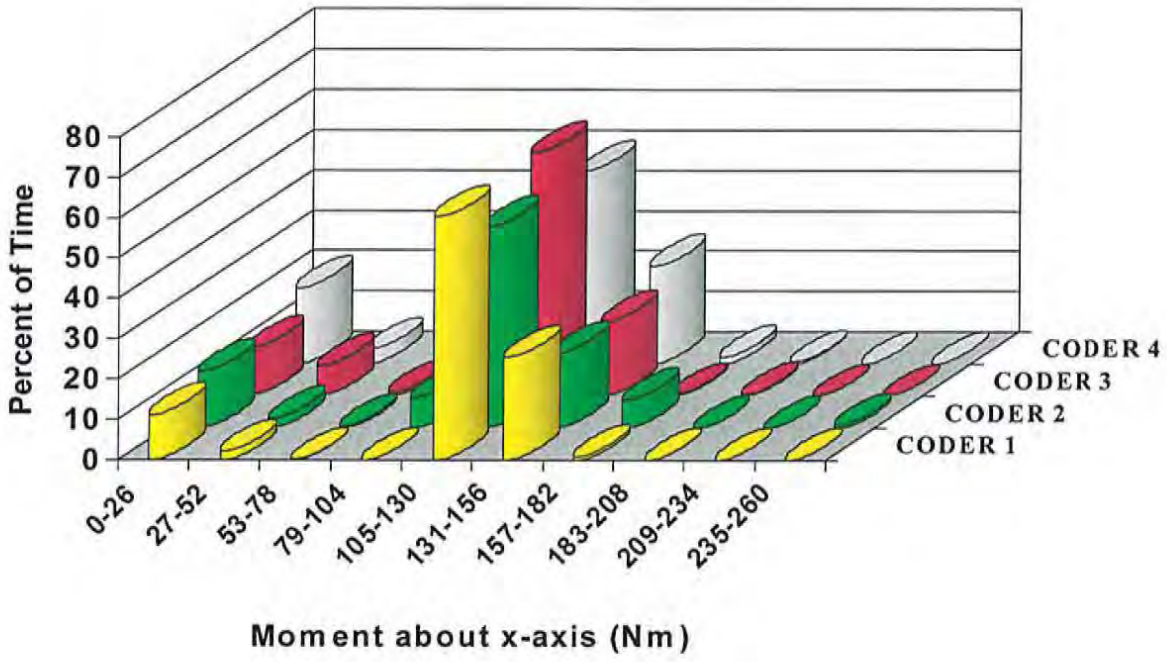


Figure C4:7 Percentile characterization of distribution of spine compression values (generic).

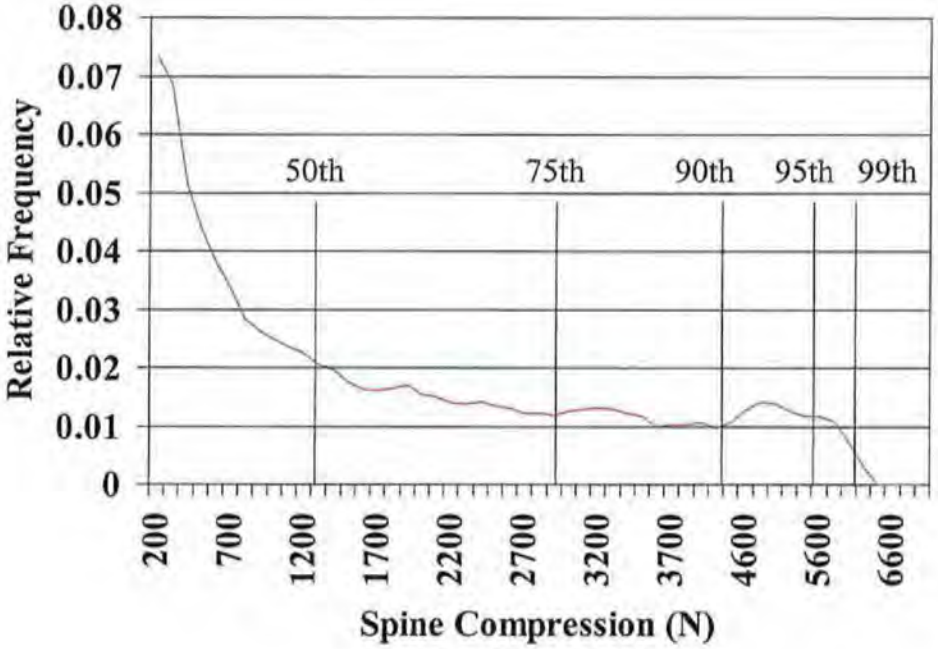


Figure C4:8 Distribution of spine compression values for laborers.

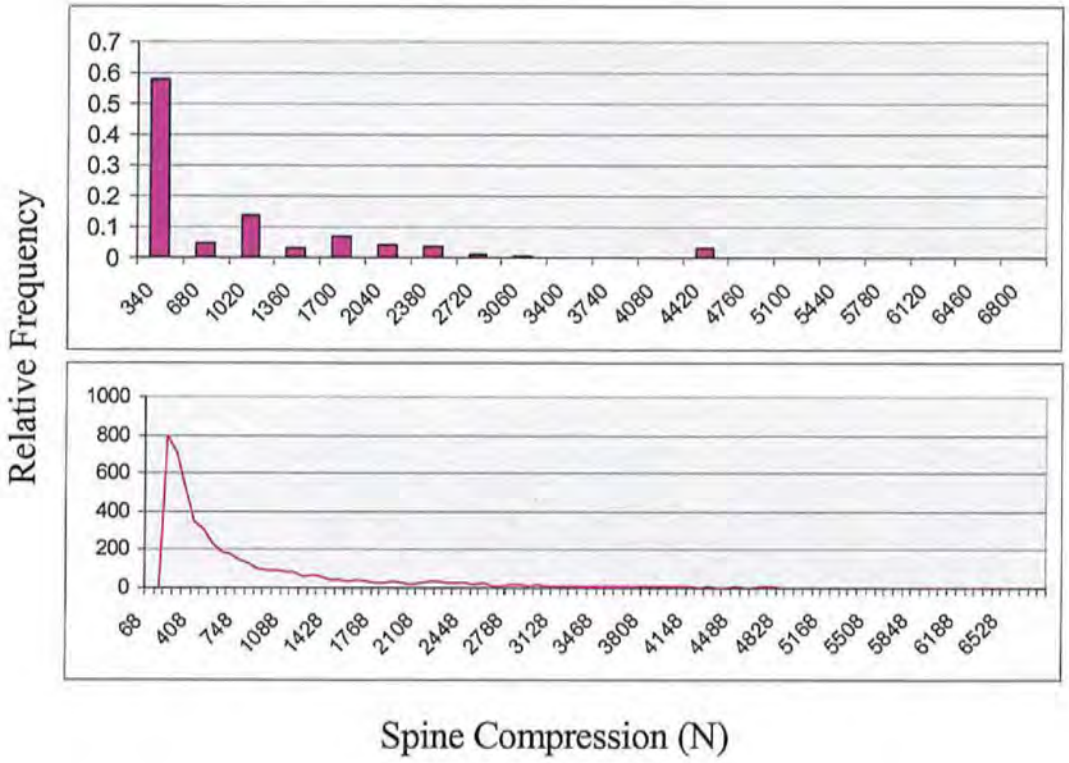


Figure C4:9 Distribution of spine compression values for carpenters.

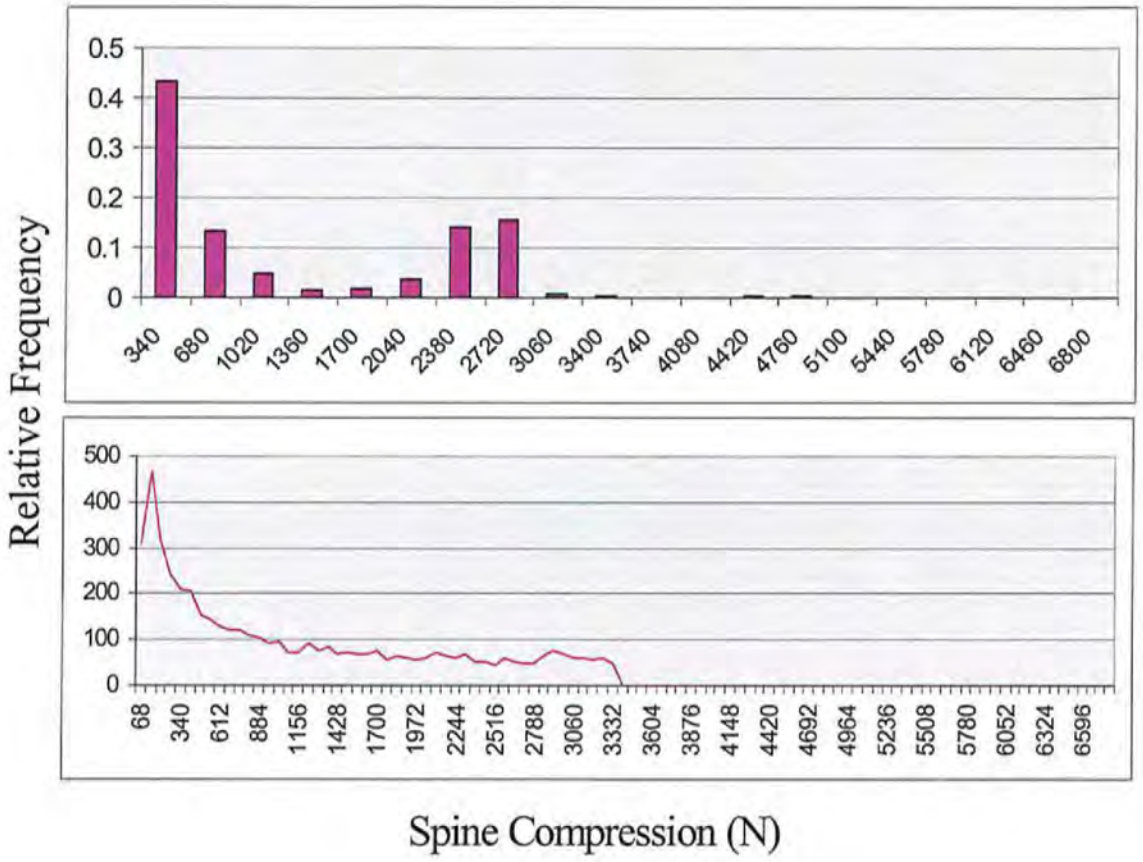


Figure C4:10 Distribution of spine compression values for foremen.

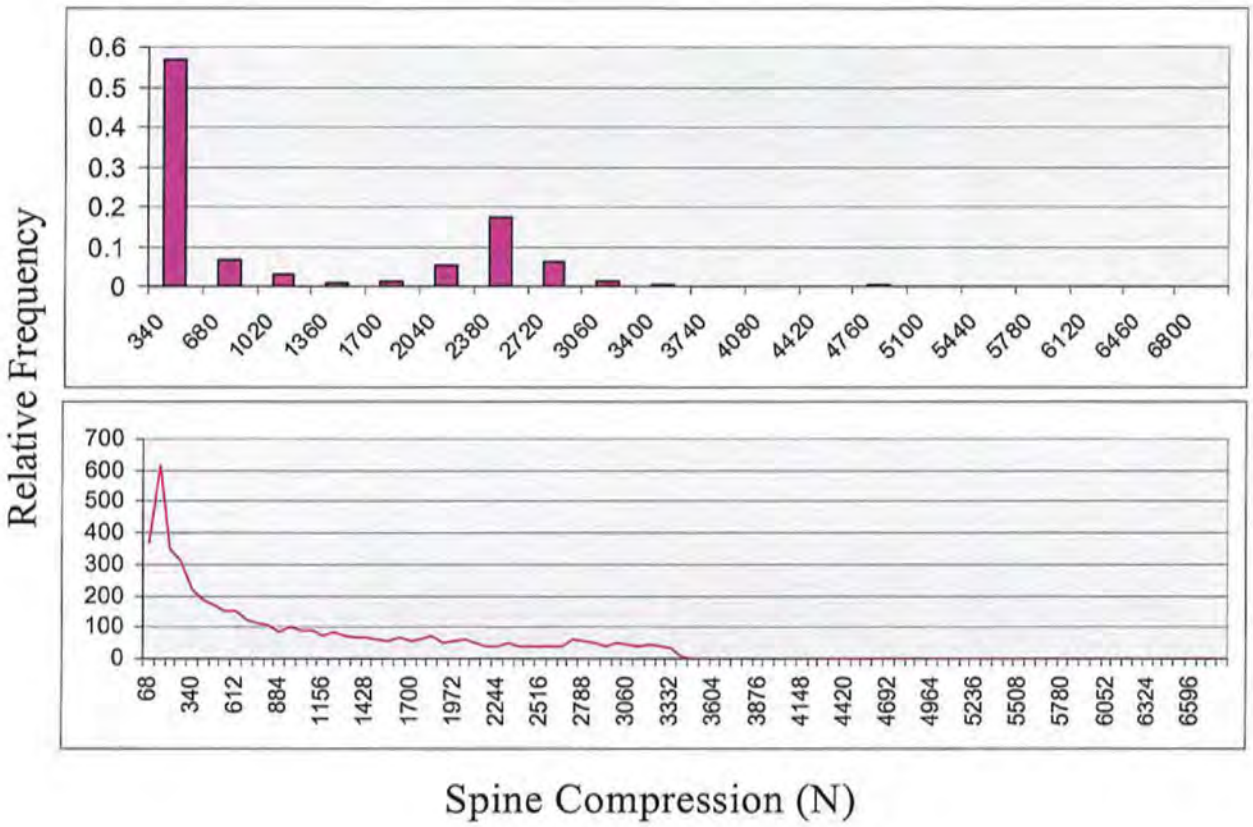


Figure C4:11 Distribution of NIOSH Lifting Index values for laborers.

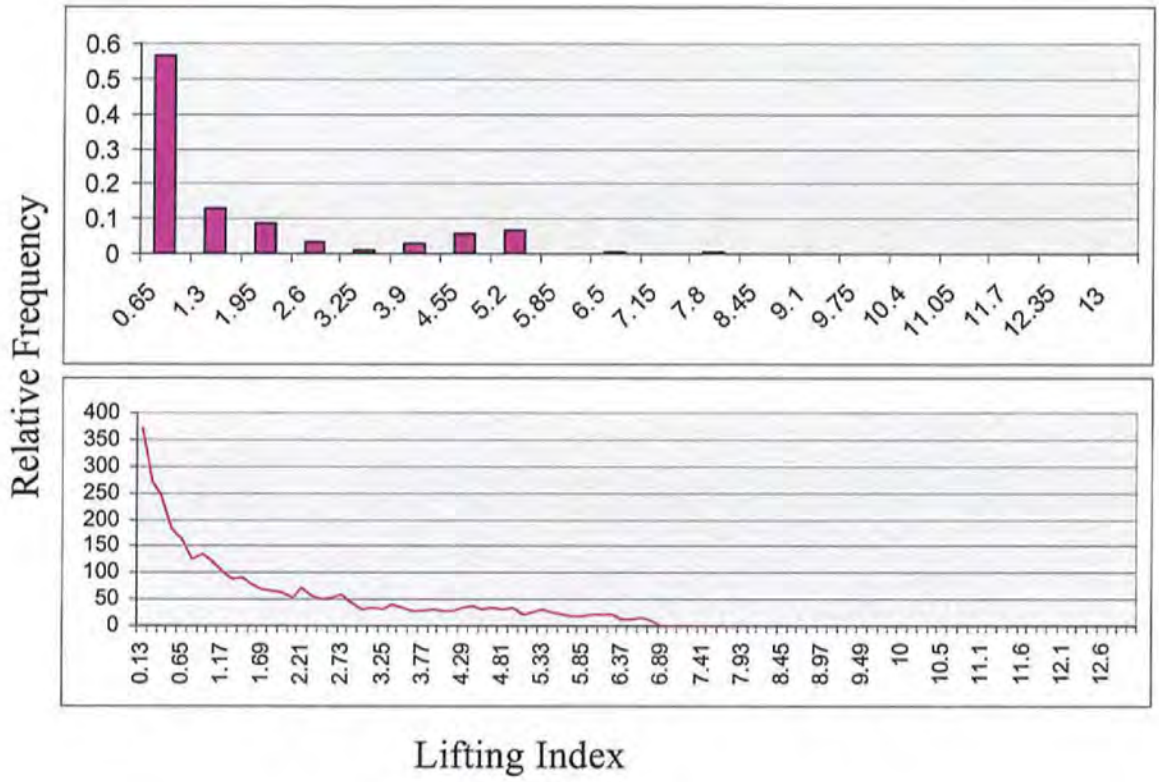


Figure C4:12 Distribution of NIOSH Lifting Index values for carpenters.

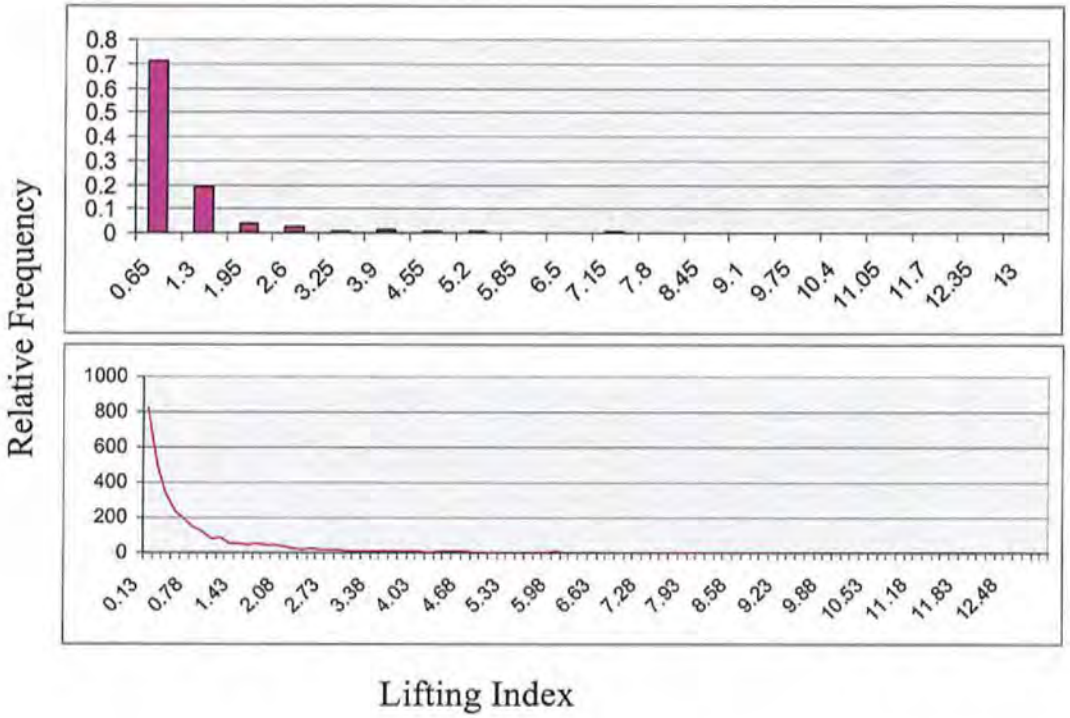


Figure C4:13 Distribution of NIOSH Lifting Index values for foremen.

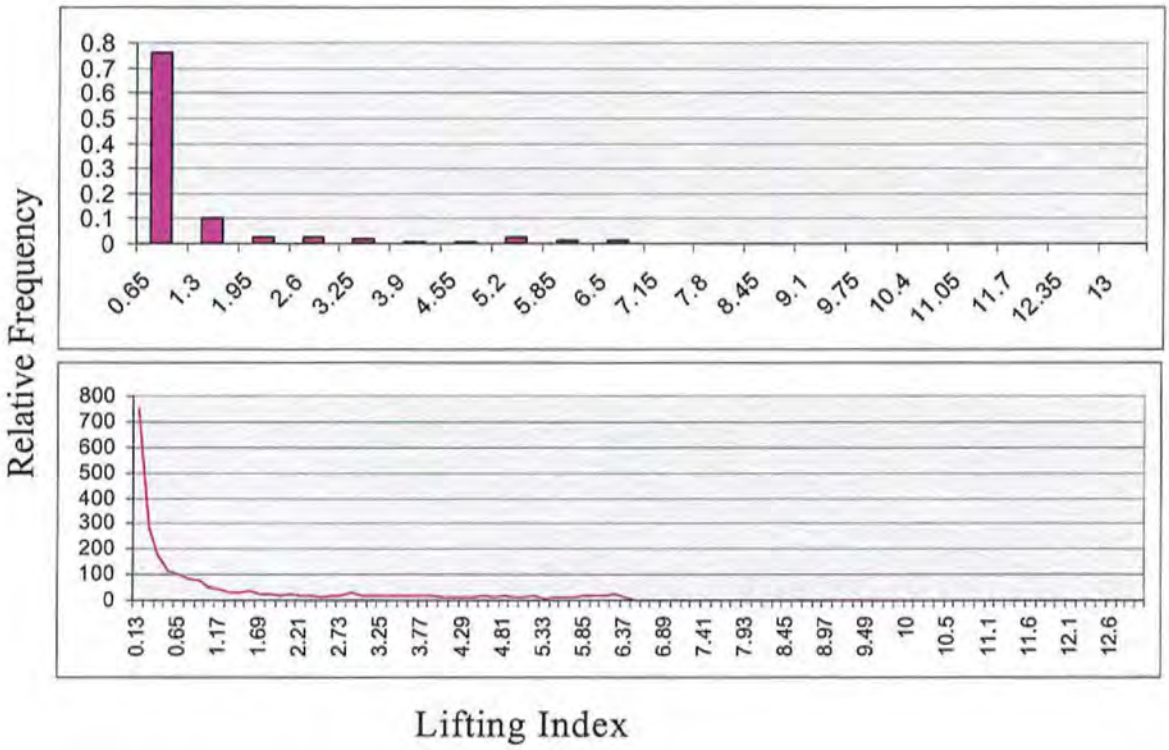


Figure C4:14 Distribution of value of Probability of High Risk Group Membership for laborers.

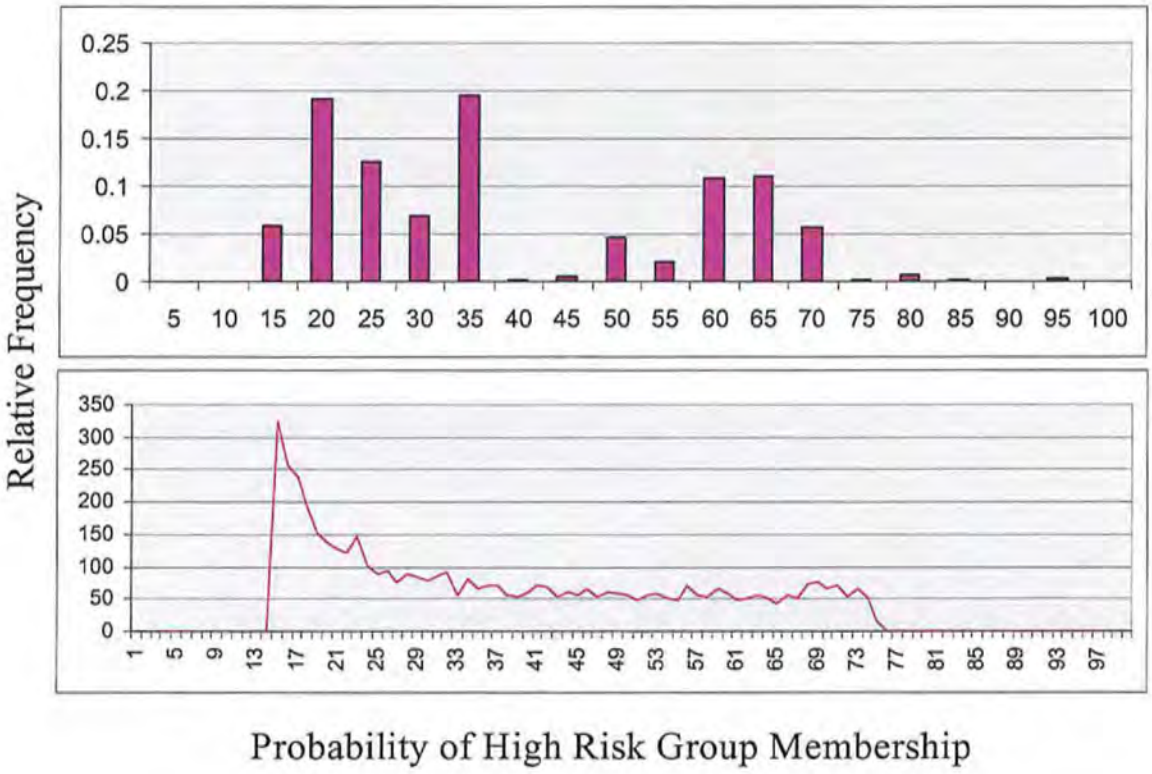


Figure C4:15 Distribution of value of Probability of High Risk Group Membership for carpenters.

Figure C4:16 Distribution of value of Probability of High Risk Group Membership for foremen.

C5 Back Injuries

AS mentioned in the previous section, in addition to the standard injury investigation questions, carpenters who experienced back injuries were asked about past work history – specifically time spent as an apprentice and periods of time as a foreman or supervisor in the last 10 years. These data were used in the estimation of cumulative occupational back stress using the Continuous Assessment of Back Stress methodology (Mirka) described in detail in the preceding section. Information collected on the activity at the time of injury was used to estimate acute spinal stress. These individuals also were asked about past history of back pain and whether any previous symptoms were severe enough to have required activity limitation, medical care or surgery.

Seventy-six back injuries were investigated. Of those 14 (8.4%) resulted in lost time from work of more than 30 days. The mechanism and nature of these injuries and characteristics of the injured carpenters are presented in Table C5:1 by time away from work following injury. Those with prolonged work loss involved a greater proportion of acute events including falls from height and being struck and were more likely to have involved fractures. The individuals with these injuries were slightly younger and had been in the union fewer years and they were less likely to have had prior history of back problems.

The majority of injuries involved overexertion, such as lifting, pushing, or pulling activities involving manual materials handling. The wide variety of materials being handled are presented in Table C5:2 including building materials, equipment, and constructed components. The estimated weights of materials being handled varied from insignificant weight to 800 pounds.

Information on spinal load and postures involved in overexertion injuries are presented in Table C5:3. A greater proportion of individuals with delayed return to work handled a load that was unexpected and were working in awkward posture. This group also involved proportionately more activities with a lifting index estimate over 5, higher mean spinal compression and mean sagital moment, and more had 75 percent probability or greater of high risk group membership. Fewer were working alone, a likely indication of the heavy nature of the work they were doing which is reflected in the spinal load measures.

The injuries in which the carpenter was struck involved an eight foot high framed wall weighing 300 pounds, 4 trusses estimated at 100 pounds each, two 2x12x16's estimated at 90 pounds, and a steel I-beam weighing over 400 pounds. In the first case, the carpenter had framed a partition and leaned it up against a wall and the wind blew it over on him. In the second case a crew was setting trusses and 4 fell over on the carpenter. In the third case, the boards were being set up to used as walkboards and they fell on him. In the last case, a 42 foot steel I-beam was being set by hand with other crew members. The beam kicked sideways and hit the carpenter.

The falls were from ladders (2), floor joists (2), trusses or rafters(2), the top plate of framed walls (2), a scaffold, a front porch roof, a foundation wall, a third floor window, a walkboard, the second level sub-floor, and an elevated work decking. Falls have been described in detail in Section C3.

Discussion

The original intent of these analyses had been to evaluate risk factors for prolonged loss of time from work following back injuries including the acute and cumulative biomechanical measures presented in the preceding section. Due to the small number of back injuries investigated, our analyses were limited to a descriptive presentation. Cumulative biomechanical load measures were only able to be estimated for 2 of the more severe injuries limiting the utility of these data in the analyses.

However, the data provide some interesting findings, even if they are of a preliminary nature. A significant proportion of back injuries (28.6%), including those which resulted in prolonged loss of time from work were the result of acute traumatic injuries involving falls or being struck. The injuries in which the carpenters were struck involved the handling of heavy materials including failure to adequately brace a framed wall. These acute events were responsible for a disproportionate share of injuries resulting in prolonged loss of time from work.

Among the overexertion injuries there was also some indication that injuries resulting in prolonged work loss were more likely to have involved greater acute spinal load measured by the lifting index, spinal compression, sagital moment and PHRGM. The workers with delayed return to work were younger, had been in the union less time, and were less likely to have had prior history of back problems – all of which go against an etiology of cumulative stress for more serious injury and resulting delayed work absence. Those with prolonged time away from work also were more likely to be working with someone else -- a reflection of the very heavy nature of the tasks being done at the time of injury.

The data also provide clear documentation of the significant spinal load imposed by residential carpentry work among those with less and more severe injury. Sixty-five percent (75%)of the manual materials handling tasks involved a lifting index of over 3 and over half (52.7%) had a lifting index of greater than five.

Table C5:1 Back Injuries and Carpenter Characteristics by Lost Time from Work, Union Carpenters 1999-2002

	Lost time >30 days (%) n=14	**Lost time <30 days** (%) n=63	**Total** (%) **n=76**
Mechanism of Injury			
Fall from height	4 (28.6%)	11 (17.7%)	15 (19.5%)
Fall same level	0 (0%)	2 (3.2%)	2 (2.6%)
Overexertion	9 (64.3%)	46 (74.2%)	55 (72.7%)
Struck	1 (7.2%)	3 (4.8%)	5 (6.5%)
Nature of Injury			
Sprain/strain	10 (71.0%)	48 (76.2%)	58 (76.3%)
Fracture	4 (28.6%)	1 (1.6%)	5 (6.5%)
Other	0 (0%)	13 (20.6%)	13 (16.9%)
Mean time in union	6.5	8.7	8.3
Apprentice	5 (35.7%)	26 (41.9%)	31 (39.7%)
Mean age in years	33.4	34.0	33.9
History of back problem[1]			
Any history	4 (28.6%)	32 (56.5%)	36 (57.7%)
Restricted activity	3 (28.6%)	24 (50.4%)	27 (38.0%)
Required medical care	4 (28.5%)	29 (34.9%)	33 (46.5%)
Surgery	0 (0%)	5 (8.6%)	5 (7.0%)

[1] Limited to those who responded to question

Table C5:2 Materials being handled by carpenters experiencing back injuries

	Frequency (%)
Materials	
Lumber*	9 (18%)
Laminated beams*	6 (12%)
Steel I-beams*	5 (10%)
Siding (masonite)	3 (6%)
Joists	2 (4%)
Roof trusses	2 (4%)
Molding	2 (4%)
Drywall	2 (4%)
Bricks	1 (2%)
Metal studs	1 (2%)
Box of nails	1 (2%)
Equipment	
Ladder and walkboards	2 (4%)
Pic (walkboards)	2 (4%)
Ladder	1 (2%)
Constructed components	
Framed wall*	3 (6%)
Plywood sheets*	3 (6%)
Vanity	1 (2%)
Desk	1 (2%)
Cabinet	1 (2%)
Door*	1 (2%)
Window*	1 (2%)
Large swing set	1 (2%)

* Involved in injury resulting in > 30 days of lost time from work.

Table C5:3 Load and Postures Involved in Back Injuries from Materials Handling by Lost Time from Work, Union Carpenters 1999-2002

	Lost time >30 days (%) n=9	Lost time <30 days (%) n=46
Working alone	2 (22.2%)	26 (55.3%)
Load was unexpected	3 (33.3%)	9 (19.2%)
Working in awkward posture	6 (66.6%)	26 (55.3%)
Spinal stress measures [1] (acute)		
Mean spinal compression	3015 (644-4664)	2255 (346-4669)
Mean sagital moment	176.4 (4-364)	132 (2-364)
Mean lateral moment	9.5 (0-85)	25.4 (0-131)
Mean twisting moment	0	3.6 (0-56)
Lifting Index (mean)	5.9 (0-9.9)	4.8 (0.0-10.5)
LE 1	11% (1)	15.5% (7)
>1-3	11% (1)	17.8% (8)
>3-<5	0% (0)	17.8% (8)
>5	77% (7)	48.8% (22)
PHRGM (mean)	54.6 (13-85)	45.8 (13-85)
<25%	22% (2)	24.4% (11)
25-<50%	22% (2)	22.2% (10)
50-<75%	22% (2)	33.3% (15)
75+%	33% (3)	20.0% (9)

[1] Could not be calculated for one injury; individual lying down and pushing up with feet.

C6 Self-insured Homebuilders Workers' Compensation Experience 1995-2000

Site of work and data sources

Computerized workers' compensation loss information from January 1, 1995 through December 31, 2000 were obtained from Canon-Cochran Management Services, Inc. the management service for a group of 5 large, self-insured homebuilders in the St. Louis, Missouri area. This is the only area of United States with a large unionized residential workforce; all five contractors hire union carpenters. Contractors were requested to report all injuries to the management company, but were required to report all injuries that involved medical care of more than $1000 dollars or lost time from work beyond the day of injury.

These data included coded descriptors of body part injured, loss cause (mechanism of injury), and nature of injury using modifications to the American National Standards Institute (ANSI) injury coding scheme. Information was available on costs incurred for medical treatment, indemnity and permanent impairment for each injury. Limited free text descriptions (50 characters) of the injuries from the first reports of injury were also provided. No information was available on sex, age, or race of the injured worker.

Union carpenters receive health and retirement benefits through trusteed health and welfare funds, and contractors hiring union labor pay into these trusts based on the hours worked by the workers they hire. The local health and retirement trust provided the union carpenter hours worked by contractor for each of the six years of interest documenting work hours at risk.

Analyses

To define injuries and time at risk on the same basis, all analyses were limited to claims of carpenters. The distributions of the coded mechanisms of injury, body parts injured, and nature of injury were examined. Total costs incurred for medical, indemnity, and permanent impairment were stratified by cause of injury. For claims that remained open at the time of the analyses (<5%) reserve amounts (estimated for the specific injury) were used in these calculations. Costs per hour of carpenter work and mean costs per claim were also calculated overall and for the more costly causes of injury by year, as were costs per hour worked for paid lost time injuries.

Carpenter hours worked were stratified by year and summed for the entire six year period. Overall and paid lost time injury rates, which occur in Missouri after the seventh day beyond the day of injury, were calculated per 200,000 person-hours of work (or 100 full-time equivalents). Stratified rates for the more costly injury causes, including injuries resulting from being struck by or against something, falls and overexertion injuries, were calculated by year.

In an attempt to learn more about circumstances surrounding more serious events and possible prevention recommendations, the text descriptions of higher cost claims, initially those resulting in over $10,000 and then $50,000 of direct costs, were reviewed.

RESULTS

Description of hours worked and injuries sustained

Over this six year period a total of 5,267,268 hours were worked by carpenters hired by these five contractors; equivalent to 440 carpenters each working 2,000 hours each year. Carpenter hours

hired per year averaged 175,575 per contractor. During the same time period, 945 workers compensation claims were filed by carpenters, of which 53 (5.6%) did not involve medical care or paid lost time (indemnity).

The distribution of the causes of injury are presented in Table C6:1. The most common causes of injury were being struck by or against something (25%), overexertion (19%), cuts (9%), falls from elevations (8%), and puncture wounds (7%).

The body parts injured in these events are presented in Table C6:2 by region of the body injured. The upper extremity was involved in over a third (38%) of the injuries followed by injuries to the lower extremity (22%) and the trunk (18%). The nature of these injuries were most commonly coded as sprains or strain (27%), cuts, crushes, or abrasions (22%), and puncture wounds (15%) (Table C6:3).

Costs

In Table C6:4 the distribution of direct costs for medical care, indemnity, and permanent impairment are presented by cause of injury. Falls from elevations ranked first in overall costs, (as well as mean, median and maximum costs per claim) while ranking third in frequency. Overexertion injuries and injuries that resulted from being struck ranked second and third in overall costs, influenced largely by their frequencies. The majority of the costs were associated with lost time claims.

Injuries that were the result of being caught were responsible for a disproportionate share of costs per claim ranking second in maximum and median costs and third in mean costs even though they

ranked 10th in frequency. The injuries which resulted in being caught most commonly resulted in an injury nature described in these coded data as 'cut/crush/mash.'

Costs per hour of work are presented in Figure C6:1 by year. Over the six year period direct costs averaged $0.66 per hour worked, with the lowest costs in 2000. Costs per hour worked declined most dramatically for injuries from falls.

Mean costs per claim by year are presented in Figure C6:2. Among the three most costly injury causes, falls remained responsible for the highest costs per claim but the costs decreased markedly (>25% reduction) from 1999. In 1999 and 2000 overexertion injuries were responsible for the greatest costs. Mean costs per fall were markedly down in 2000 averaging approximately $7500 per fall compared to the range in previous years of $30,000 per fall (1995) to $12,000 per fall (1998).

Injury rates

The overall injury rates was 35.9 per 200,000 hours worked, and the paid lost time injury rate was 14.5 per 200,000 hours worked. Overall and lost time injury rates by year from 1995 through 2000 are presented in Figure C6:3. The highest rates occurred in 1997 and the lowest rates were seen in 2000. Overall rates and rates of lost time injuries declined 16% and 12%, respectively, over the six years with declines of 40% and 38% between the peak years of 1997 and 2000.

Patterns for the more costly causes of injury were variable (Figure C6:4). Injuries from being struck by or against something increased particularly in 1998 but declined in 1999 and 2000. Falls from elevations increased slightly in 1997 from the baseline year, but remained lower after that. Overexertion injuries fluctuated but remained slightly higher in 2000 than in 1995.

Free text injury descriptions

Higher cost claims

There were 136 claims (14.4%) which resulted in direct costs of over $10,000; these injuries cost a total of $4,597,891, representing 83% of all direct costs. These more serious injuries are described in Table C6:4. Falls were responsible for 37% of the costs associated with these injuries and the falls occurred from a wide variety of work surfaces. Overexertion injuries primarily involved lifting with the most common materials being framed walls, steel beams, or wood (not described in detail). Carpenters were also struck by a variety of objects with the most common being nails from pneumatic nail guns which were also associated with the puncture wounds. Walls that fell were involved in injuries classified as both caught and struck by.

There were 21 injuries with costs over $50,000; these 2.2% of claims resulted in $1,961,704 (43%) of direct costs. Nine (42.9%) of these were falls; four (19%) were the result of walls falling, including one incident in which the wall was being handled by a crane; two (9.5%) occurred when lifting walls; and two (9.5%) from setting steel beams. The remaining three involved head, shoulder and back injuries which were not well described in the available text.

Discussion

Summary

Data from a workers' compensation management company were combined with union records of hours worked to examine injury patterns and rates for union residential carpenters for a six year time

period. Injuries were most commonly caused by the carpenter being struck by or against something (including being rubbed or abraded), overexertion, and falls from heights.

Overall, falls from elevations, which ranked third in frequency, were responsible for the highest costs and the highest costs per claim. The rate of falls, as well as the mean costs per fall and cost for falls per hour worked all declined markedly over the period of observation. Considering that costs for medical care and wages (on which indemnity payments are based) increased in this time period, the cost declines are particularly impressive. Injuries resulting from being struck by or against something declined 35% over this six year period, but with lesser declines in associated costs. Overexertion injuries, largely involving manual materials handling, increased 20% in 2000 compared to 1995 but without the corresponding increases in cost.

Although overexertion injuries resulted from multiple tasks, the majority of costs associated with these injuries resulted from two tasks - lifting framed walls and setting steel beams. Unfortunately, from the brief descriptions in the electronic data the size, weight or conditions on site where these walls were lifted or beams set could not be determined, nor could the number of workers involved or their levels of experience or training.

While the pattern of these injuries are consistent with reports of other residential construction workers (Dement and Lipscomb, 1999) and residential carpenters in particular (Lipscomb, Dement et al, 2003). The injury rates reported here are higher than those reported by the Bureau of Labor Statistics (BLS) for the same time period, but are not really comparable to BLS rates. Higher rates have been reported previously among union carpenters in the State of Washington (Lipscomb, 1996) and by Glazner et al. (1998), in the building of the Denver International Airport. These studies,

representing commercial and residential sectors, also used hours worked as measures of time at risk, whereas BLS rates are based on estimates of aggregate hours for the sector.

The BLS reported declining injury rates during this period but not of the magnitude seen here. These homebuilders took steps to decrease injuries on their sites during this time period including hard hat/safety glasses policy, required training in use of pneumatic tools, addition of designated safety personnel, and changes in fall prevention policies. Policies were not mandated by the group, and each contractor made decisions about what steps he/she would take for their own companies. The workers' compensation management company also worked to decrease costs for all the contractors through claims management and injury prevention efforts. These included job site surveys with written reports, updating of safety manuals, investigation of large losses including collection of information from the injured worker, on site tool box talks and briefings or "mini tool box talks" with job foremen about safety issues. These efforts likely made substantial contributions to the observed decline in both rates of injuries and costs involved.

Limitations and Strengths

As with any claims analyses, the findings are based on events that were reported. Anything that influenced whether a person filed a workers' compensation claim will be reflected in the findings. Although total carpenter time at risk was available, no information was available about time exposed to any given risk factor such as work at heights, specific tool use, etc. No details were available on the circumstances surrounding the injuries beyond what was available from the first reports which could have been more revealing.

Data were used from a group of large, self-insured homebuilders who hired union labor, and for several reasons the data may not be representative of the homebuilding industry. The findings may, in fact, fail to adequately represent risk across this sector of the industry for several reasons. Union carpenters typically go through a required four year apprenticeship program involving classroom instruction and supervised work. In addition, much homebuilding, is done by smaller contractors who may not have the same safety resources. While there were significant improvements over the six year period, and the overall effect of these efforts appear obvious, the contribution of individual components made by the homebuilders and the management company could not be assessed through these analyses.

Despite these limitations, there were several strengths to this approach, the major one being that, while not perfect, the methods allowed insight into the experiences of a group of construction workers who are particularly challenging to study. Through computerized records, full ascertainment of reported injuries was available, and by using a union workforce an accurate measure of work hours was possible. The combined data sources provided events of interest and person-time at risk over a 6 year period, allowing rate calculations and identification of patterns of injury risk over time. Although very limited (50 characters), the free text information was much more useful than coded data in understanding the circumstances surrounding these injuries and making concrete preventive recommendations.

Conclusions/Recommendations

Residential carpentry is hazardous work, but these data also document significant improvement in safety performance over a six year time period among a group of self-insured contractors. The group would not have been able to self-insure, unless they had reasonable safety records. As members of the self-insured group, each contractor had the incentive to improve not only his/her own work site safety performance, but also those of others in the self-insured group.

Cost data provide a measure of injury severity that is useful in focusing prevention efforts. Specifically, it was clear from these analyses that there are a group of activities or tasks associated with particularly severe injuries. Falls from elevations resulted in serious injuries which were responsible for a disproportionate share of costs. Carpenters often work at elevations and the surfaces from which they fell were varied -- consistent with the varied nature of their work. This indicates the need for a multi-faceted approach to fall protection including comprehensive training efforts, appropriate fall protection plans, and use of personal protective equipment. The data indicate that efforts should include ladder safety, safe work practices around openings (stairwells, sub-flooring, windows) and in trusses, on roofs, and on scaffolding.

Raising and bracing framed walls and handling beams are activities that should be targets for innovative engineering improvements. In the absence of engineering solutions careful attention to adequate manpower to avoid these serious injuries would be prudent. Cranes provide assistance, but injuries result form those as well, and crews and operators must be appropriately trained to use these safely.

Methods to prevent injuries from power tools, particularly pneumatic nail guns/staplers are needed. Although these data do not identify specific prevention strategies, other data indicate prevention should be through both engineering improvements and training (Dement and Lipscomb, 2003 and Lipscomb and Dement 2003).

Relatively few injuries involved a worker being caught in or between objects, but these injuries were also responsible for a disproportionate share of costs. The brief text descriptions identified that these high cost events resulted, in large part, from carpenters being caught by walls that fell over. Careful attention to appropriate bracing of walls is indicated. Supervisors and foremen should be aware of the risks and apprentices and more seasoned workers should be trained in appropriate techniques to safely secure walls as the structure is going up. Based on the small number of events of this nature, the vast majority of walls are braced adequately. However, being hit by a 200-300 pound wall can cause a devastating injury.

Residential construction has changed considerably in the last 20 years. Many new homes have more square footage, large open expanses, higher ceilings, and steeper roofs, to name a few common examples. These architectural changes result in longer, taller, and consequently heavier walls; increased needs for heavy steel or laminated beams that can provide wider expanses of support; and requirements for carpenters to work at significant heights. Safety efforts in this sector of construction must keep pace with these innovations.

Key Points

- Overall, falls from elevations are the most costly injuries responsible for the greatest overall costs (even though they rank third in frequency) and the greatest cost per claim. However, fall rates for this group of self-insured contractors declined 46% since 1997, and total costs for falls fell to a rank of 4th in 1998, 2nd in 1999, and again 4th in 2000. Mean costs per fall were markedly down in 2000 averaging about $7500 per fall compared to a range in previous years of $30,000 per fall (1995) to $12,000 per fall (1998).
- Improvements were not limited to falls. Injuries resulting from being struck by or against something declined 35% over this six year period. Overexertion, largely involving manual materials handling, injuries are up 20% in 2000 compared to 1995, however, the rate is lower than in the three preceding years (the rate was up 60% in 1998 compared to 1995).
- Back injury costs of at least $280,834 (25.7% of costs for back injuries) were not the result of manual materials handling tasks or exertion. These injuries were the result of falls, being struck by walls, or slipping. The greatest costs for back injuries are from injuries resulting from lifting framed walls or setting steel beams.

Table C6:1 Causes of work-related injuries, union residential carpenters, 1995-2000

Cause of Injury Frequency	Percent	
Struck by or against	236	25.0
Overexertion (lifting, pushing, pulling)	180	19.1
Cut or rubbed	83	8.9
Fall from elevation	72	7.6
Puncture	62	6.6
Fall same level	49	5.2
Repetitive Action	48	5.1
Foreign body	48	5.1
Bodily Reaction	45	4.8
Caught	36	3.8
Slip/ trip	34	3.6
Stepped in/ on	22	2.3
Motor vehicle	1	0.0
Other/missing	29	3.1
Total	**945**	**100**

Table C6:2 Body parts injured, union residential carpenters, 1995-2000

Body Part Injured Frequency	Percent rcent	
	Frequency	Percent
Upper extremity	*360*	*38.2*
Hand or fingers	225	23.8
Forearm /wrist	45	4.8
Shoulders	43	4.6
Elbow	17	1.8
Upper extremity (not described)	30	3.2
Head and Face	*102*	*10.9*
Eyes	56	6.0
Mouth/Teeth/Throat	20	2.1
Head	17	1.8
Face	9	0.95
Lower extremity	*208*	*22.2*
Knee	52	5.5
Foot/toes	44	4.7
Ankle	37	4.0
Thigh/Hips	10	1.1
Groin	14	1.5
Leg (not described)	51	5.4
Trunk and Chest	*171*	*18.2*
Back	139	14.7
Chest	13	1.4
Abdomen	10	1.1
Neck	8	0.85
Trunk (not described)	1	0.11
Multiple parts	36	3.8
Other	68	7.2
Body system	3	0.32
Other/missing	65	6.8
Total	**945**	**100.0**

Table C6:3 Nature of injury, union residential carpenters, 1995-2000

Nature of Injury	Frequency	Percent
Sprain/Strain	254	26.9
Cut, Crush/Mash, Abrasion	206	21.8
Puncture	140	14.8
Soreness/Pain/Swollen	104	11.0
Fracture	60	6.4
Bump, Bruise	52	5.5
Foreign Object	46	4.9
Multiple Injuries	14	1.5
Carpal Tunnel/tendinitis	12	1.3
Scratch/Irritation	10	1.1
Hernia	9	0.95
Dislocation	7	0.74
Concussion	5	0.53
Herniated Disk	3	0.32
Sting	3	0.32
Conjunctivitis	2	0.21
Infection	2	0.21
Avulsion	2	0.21
Bite	2	0.21
Other/missing	12	1.3
Total	**945**	**100**

Table C6:4 Costs[1] of Injury Among Carpenters by Cause of Injury, Union Residential Carpenters, 1995-2000

Cause of Injury (n)	Sum of costs (rank)	Median	Mean	Maximum
Struck By/Against (236)	$ 909,815 (3rd)	450	$ 3,855	$ 71,890
Overexertion (180)	1,152,921 (2nd)	725	6,405	87,827 (3rd)
Cut or Rubbed (83)	137,620	340	1,658	31,924
Fall from elevation (72)	1,624,186 (1st)	2,766 (1st)	24,558 (1st)	199,964 (1st)
Puncture (62)	53,285	428	859	10,829
Fall Same Level (49)	151,532	408	3,093	38,815
Repetitive Action (48)	293,642	946	6,118	47,417
Foreign Body (48)	14,125	176	294	1,836
Body Reaction (45)	285,604	1,009 (3rd)	6,347	29,190
Caught (36)	404,962	1,214 (2nd)	11,249 (3rd)	99,735 (2nd)
Slip or Trip (34)	142,026	830	4,177	46,854
Stepped In/On (22)	73,730	215	3,488	43,863
Motor Vehicle (1)	14,857	--	$14,857 (2nd)	14,857
Overall (945)	$ 5,510,324		$ 5,510	$ 199,964

(1) Incurred costs for medical care, indemnity, and impairment

Note: Other and missing (n=29; costs=$252,019) not presented, but included in overall category.

Table C6:5 Injuries resulting in greater than $10,000 in costs[1], union residential carpenters, 1995-2000

Cause of Injury (n= number of injuries)	**Sum of costs** (% of costs > $10,000)	**Description** (n=number of injuries)
Bodily reaction (13)	$ 232,727 (5.1)	Twisted knee (6) Strained ankle/foot (5) Back pain (1) Hernia and back pain (1)
Caught (7)	$ 345,179 (7.5)	Wall fell on carpenter (3) Glove caught in saw (1) Hand/fingers caught against crane (1), between studs (1), by beam (1)
Fall from height (28)	$ 1,704,101[2] (37.0)	Through opening/landing (4), from ladders(3), trusses (2), sub-floor(2), roof (2), scaffold (1), bucket (1), window (1), foundation (1), 3rd floor (1), unspecified (10)
Fall from same level (5)	$ 109,943 (2.4)	Slipped on: siding(1), stud(1), wet ground(1), not described (2)
Overexertion (30)	$ 931,221 (20.3)	Lifting/holding : walls (5), steel beams (4), wood (3), joists (2), timberstand (1), beam (1), drywall(1), nails (1), unspecified (3) Pulling: trusses (1), soffit (1) Carrying: cabinet (1) Other: Hurt elbow starting compressor (1)
Motor vehicle (1)	$ 14,857 (0.3)	Hit by truck on job site (1)
Repetitive action (10)	$ 239,222 (5.2)	Pain in wrist (4), hand (1), elbow (1), shoulder (1), knee (1), carpal tunnel/numbness (2)
Cut/rubbed (4)	$ 87,972 (1.9)	Cut finger/hand on: saw (1), lumber bands (1), gusset (1), not described (1)
Slip/trip (4)	$ 95,419 (2.1)	Slipped carrying plywood (1), down roof (1), in mud (1), not described (1)

Cause of Injury (n= number of injuries)	**Sum of costs** (% of costs > $10,000)	**Description** (n=number of injuries)
Struck by/against (28)	$ 697,050 (15.7)	Falling objects: plywood/boards, including stack of 2x12s (6), wall (2), beam/joists (3), siding (1), drywall (1) Tools: Nail gun (8), power saw (2), hammer (1) Eye injury from: strip of wood (1), nail (2) Hit head on ceiling (1)
Puncture (2)	$ 25,983 (0.6)	Nail gun shot nail in shin (1), shot staple in knee (1)
Stepped in/on (2)	$ 57,550 (1.3)	Twisted leg walking on job site(1), twisted knee stepping over trusses (1)
Other (2)	$ 56,693 (1.2)	Knee injury not described (2)
Total (136)	$ 4,597,891 (100)	

1 Direct costs for medical care, indemnity, impairment

2 Costs exceed those in Table 4; 2 injuries coded as 'other' were high cost falls identified through text review.

Figure C6:1 Incurred cost per hour worked by mechanism of injury, union residential carpenters, 1999-2000

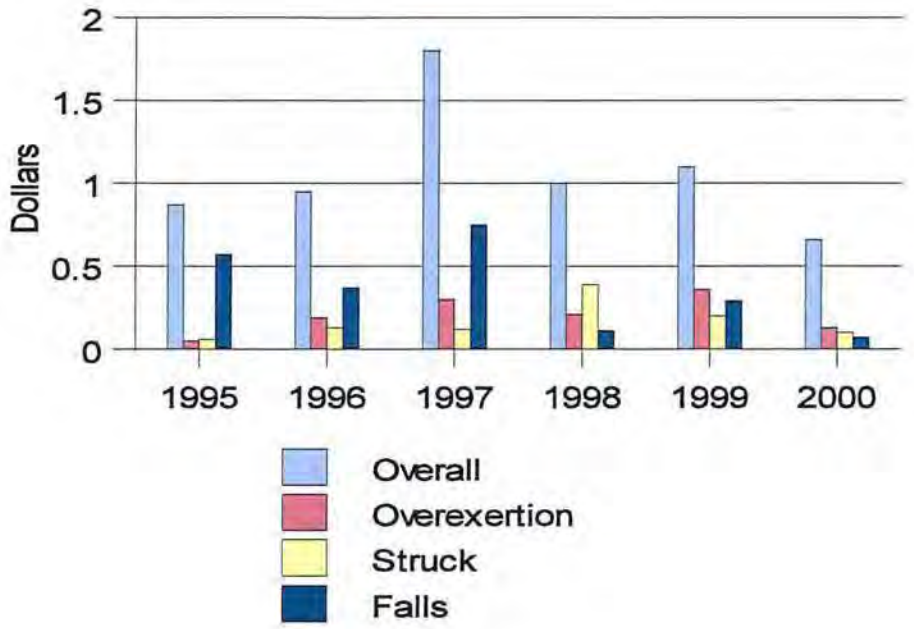


Figure C6:2 Mean cost per claim by mechanism of injury, union residential carpenters, 1995-2000

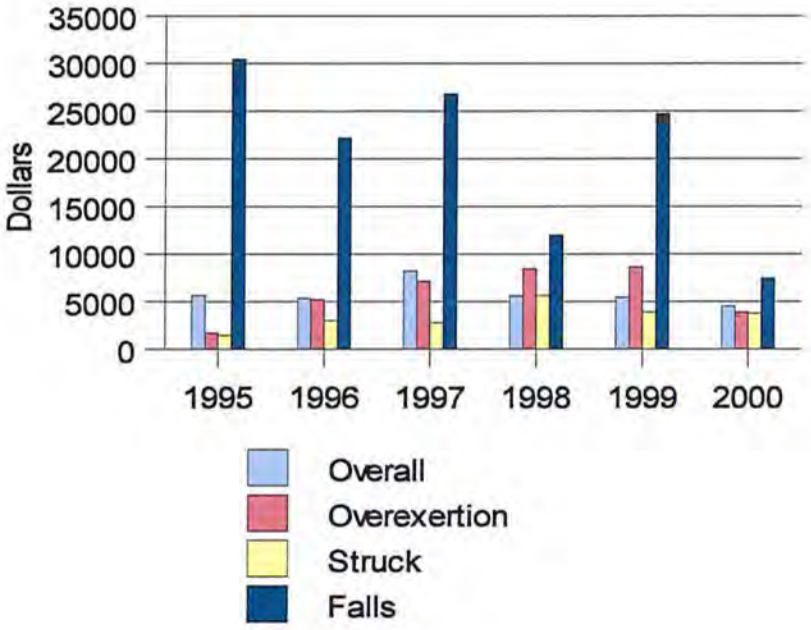


Figure C6:3 Overall and lost time injury rates, union residential carpenters, 1995-2000

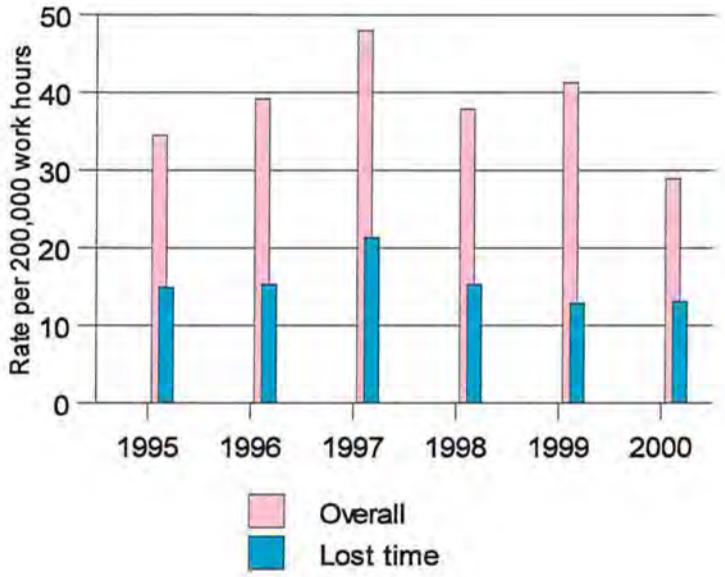
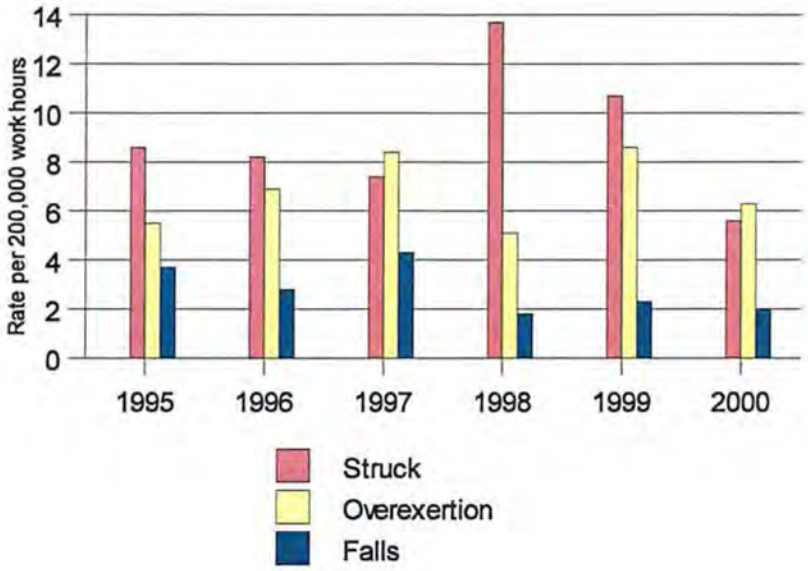


Figure C6:4 Injury rates by cause, union residential carpenters, 1995-2000



C7 Focus groups

Findings from the focus groups are summarized below under key headings. Fifty-four participants were apprentices, taken consecutively on days that were convenient to conduct the sessions. The majority were residential apprentices with at least 6 months of experience, although the groups included commercial and industrial apprentices and apprentices up to fourth term. Based on attrition reports from the apprenticeship school, a number of apprentices would already have dropped out of the program in these early months. One group was conducted with eleven residential journeymen. The journeymen had been in that capacity for 3-20 years. Seven (64%) had completed an apprenticeship program; the others had grand-fathered in based on their non-union carpentry experience.

These carpenters reported, overall, that most things that should be done are done – somewhere by somebody – but they are not accepted industry wide.

Career Decisions

The reason many participants gave for choosing to go into the trades was primarily the type of work. The apprentices expressed satisfaction at seeing a tangible product, working outdoors, moving from job to job and site to site. There was satisfaction in being able to meet physical and fear factor demands of the job – " I'm doing a man's job." One man noted that he had worked at a desk job and couldn't stand it.

The trade is not easy to break into, with one barrier being the letter of intent. Although the letter is not a commitment to hire, they can be hard to get, particularly from a chosen contractor. Having a relative or a friend in the trade seemed the surest shot at getting a desired letter. Choosing carpentry for many may

be more of a factor of who they know than of exactly the trade they are looking for. If they knew a laborer or a cement mason they might have gone a different way.

Choosing to go union seems to be a more deliberate choice. People could quickly run down a pretty consistent list of reasons -- more money, security, a grievance system, someone to stand up for you, pension, training, and job satisfaction. Participants seemed pretty well grounded about what the union did for them.

Apprentice participants who went into commercial or industrial work, as millwrights, seemed to have lucked into those jobs. Although the jobs seemed more desirable in many aspects they did not carry the panache of residential work. They were less macho -- less pain, less fear, less freedom, less mobility. Residential carpenters thought they were learning more basic carpentry skills. Residential apprentices saw commercial work as something they might want to do later – after they had learned more skills.

Job Sites

Industrial, commercial, and residential sites were described in very dissimilar terms. Work on industrial sites was more characteristic of manufacturing work than typical construction work. Protective equipment was not only provided but its wear was often strictly enforced. Training and supervision were abundant, at least relative to the other areas. More attention seems to be paid to job quality than to speed. The few participants who work industrial seemed to have a sense of being fortunate.

Commercial work was described more in construction terms but it was a lot better than residential by most objective measures. Commercial work pays more, is not as rushed, provides better supervision, and uses more mechanical assists such as cranes, for example. The down sides reported were bigger

hazards (not more prevalent, just physically bigger and thus posing greater potential for severity). There was less opportunity reported to learn a wide range of carpentry skills in commercial work.

Residential work was described as extremely demanding both physically and psychologically. The physical demands of heavy lifting (packing lumber, setting beams) did not seem to be beyond the ability of anyone participating though these demands may have been for apprentices who had already dropped out. At six months of experience working at heights was still viewed as a challenge to many. Standing, walking, stooping on a 3.5 inch wide top plate was mentioned most often. There was clearly great pride in being able to meet those challenges – enough that many could still admit to being terrified at first and even still.

Residential job crews varied somewhat but most consisted of a small team of men (3-5) working very rapidly to erect a structure. At times the majority of the crew are apprentices and later term apprentices may function as job foremen. These was little direct supervision or outside support from equipment or laborers reported. When additional manpower is needed for very heavy tasks, crew from another site are recruited to help. Clutter seemed to be pervasive.

The common theme on residential sites seemed to be "time is money – and there isn't enough of either." Everyone seems to know how many hours have been allotted to finish a structure, and when they are behind the curve. The perception is that in commercial there are both the time and the money to do things right, but there isn't in residential.

There was recognition among apprentices that safety is more variable, even negotiable, on residential sites than commercial sites. There was, however, a great deal of variation reported between contractors and foremen. Where things were done right and attention was paid to safety, they were respected. Apprentices volunteered names of "safe contractors" who make a commitment to their

apprentices, as well as those who are known to hire anyone with the plan to use them as laborers knowing many will leave the apprenticeship.

Progression of tasks and exposure differences between apprentices and journeymen

In the industrial area, task progression seemed to be fairly methodical. In commercial there was less job variety described, and some respondents were stuck on the same task (interior structures) consistently because they knew that task well.

In residential the first task was uniformly carrying, or "packing," lumber. That task might last a few weeks to months depending on the crew, foreman, individual skill, and whether a newer apprentice arrived. Journeymen freely discussed "having paid my dues" hauling materials, and that those tasks were jobs " for the cubs." The journeymen report this is in part helping the crew with a task they have owrked beyond and also an opportunity for the apprentice to show "their hustle." During the early period they want to see an apprentice show up, act enthusiastic, and "haul more lumber than asked."

Beyond carrying lumber, tasks were reported to be assigned primarily by need, and sometimes just by where a person was at a given time. Training was minimal to non-existant at times. The apprenticeship school does not teach job skills before apprentices go on the inital job and on the job training at the early stages may be the absolute minimum needed – or less. Event the best on the job training was often prefaced by "pay attention, cause I'm only going to show you this once."

Apprentices do much of the pneumatic nailing on framing jobs. This was viewed as an early task someone can be transitioned to from hauling. Sometimes training was limited to "don't shoot yourself." Use of a circular saw was also seen as a relatively early task, but one that required more training/skill in part

because of the need to know how to measure and make the appropriate cuts. Little safety training was incorporated into early experiences with these tools as well.

Learning to do dangerous work

In terms of learning to do dangerous work, the industrial sector, again, was described in relatively glowing terms. Residential apprentices described essentially learning by jumping in and doing. They would first work on setting a beam or raising a wall, for example, by being one of the group providing support while more experienced carpenters set them in place. Other learning was by observation.

Although the journeymen said they would assume an apprentice knew nothing, some of their other rhetoric would indicate that is not always the case. For example, journeymen reported the expectation, than even an early apprentice would know basic rules of ladder and scaffold safety - how to set the ladder, which ladders to use, height needed, etc. Apprentices lack this knowledge early in their career at times when they are expected to use ladders and scaffolds.

In terms of teaching apprentices to use nail guns or circular saw, they reported showing them how to "hold your hand back" from a nail gun and talking about how saws might bind and how to keep their hand "out of the way." One journeyman explained that "sometimes you just have to learn the hard way" as he acknowledged that all carpenters experience nail gun injuries. Apprentices were described as being more quick to report their injuries, a reason for their higher injury rates. A journeyman might " remove a nail he had shot in his hand, duct tape it, and keep on going," when an apprentice "has to be taken to the hospital."

On residential sites the foreman might be a senior apprentice. No one described any systematic approach to training or mentoring, although some apprentices had experienced very good examples of teaching from more experienced carpenters.

Risk Perception

Consistently apprentice carpenters in residential felt working at heights, particularly on the top plate of a framed wall or "riding the ridge" when setting trusses, were the most dangerous aspects of their jobs. One carpenter described changes he had seen in residential building in his lifetime that affected safety..

"The houses are getting bigger, are getting taller,. Ceilings are getting higher, vaults are getting bigger, the houses are phenomonal. They're getting to a point now where you'll be sixty feet in the air a lot. You get these forty foot houses, I mean, walkout basements, you're up another twenty foot with the peak. And you're riding that ridge. You know, don't fall. I mean they say "well set ladders, and set your gables first." That sounds nice in a perfect world."

In contrast when asked about covering openings, stairwells, or windows these were not perceived to be high risk areas for falls. " Falling out of windows and falling in openings and all that.. That's ridiculous. You got to be pretty stupid to walk yourself right off the window. That's the kind of things they're wanting you to do; board off a stairwell and windows, guys. That's not where we're falling, we're falling through floors from rafters."

Apprentices also reported that they had difficulty transferring training from school to the job sites. They describe journeymen getting too comfortable with doing things "their way" and getting careless. "Once you get used to working in an environment that unsafe, and you get used to working unsafe, then

being unsafe is not unsafe to you anymore. It's just the norm." Journeymen reported that apprentices can practice working at height (walking a beam for example) but that they felt capable of being able to tell "whether an apprentice has it" and is going to be able to work at height in a few days.

Another issue that apprentices raised regarding risk was working in mud. They describe that "you don't know what that is like until you do it. You don't realize how heavy it is, how hard it can make it to work safely. And someone is always going to get hurt; slip, pull a muscle, fall."

Improvement in apprenticeship training

Apprentices and journey men had concrete suggestions for improvements in apprenticeship training. Journeymen wanted apprentices to know how to use a framing square, speed square and tape measure when they walk on the job. They also should know how to safely use pneumatic tools, including how they feel to operate and recoil issues. They should be familiar with a circular saw, a reciprocating saw, and drills, and they should know how to drive nails with a hammer. These were all tasks that the apprentices also reported would have been useful very early in their work.

Apprentices also reported the need to know different types of lumber and how to carry materials. They cited examples of lifting and carrying lumber through doorways. They felt the labor history training they are required to have very early would have been more appreciated later, and would have allowed more time for practical training very early. They would like more practice early on in laying out and actually framing a wall. They wanted more time actually using a nail gun in tasks they will face on site such as these instead of making a toolbox , for example. Other things asked for included theories and practice bracing, making a walk board and securing it, and getting a pick board up a scaffold.

C8 DISCUSSION

The pattern of injuries among these carpenters was as expected - commonly involving being struck by or against something, overexertion, and falls. Injuries from pneumatic nail guns were the most common cause of injuries in which a carpenter was struck. Manual materials handling injuries often involved very heavy objects and tasks - setting of I-beams, trusses, pre-manufactured beams, or sheets of 16 foot drywall, for example. The stress associated with manually moving these objects was compounded by the fact that there are few workers on any given residential site. Acute injuries were predominantly associated with this very heavy work, although the contribution of stress over time could not be measured. Falls occurred from a variety of surfaces making prevention challenging. The injuries that resulted from falls, as well as those from being caught, tended to be more severe. Poor housekeeping was involved in circumstances leading to the majority of injuries resulting from same level falls, as well as some overexertion injuries - particularly moving large objects where view was obstructed. On residential sites, injuries most commonly occurred in framing followed by exterior finish and roofing, a likely reflection of the time union carpenters spend working in these stages in constructing homes.

The overall estimated injury rate (>16 per 200,000 hours worked) is considerably higher than recent Bureau of Labor Statistics (BLS) rates for the construction trades (8.3 per 200,000 hours worked) despite the fact that there was less than complete ascertainment of injuries. Injury rates higher than those reported by BLS have been reported previously among union carpenters in the State of Washington (lipscomb, 1996), and by Glazner et al. (1998), in the building of the Denver International Airport. These studies, representing commercial and residential sectors, also used hours worked as measures of time at

risk, whereas BLS rates are based on estimates of aggregate hours for the sector. The two methods of rate calculations consistently reveal quite different results and seem to indicate that the rates are not reasonable comparisons.

Consistent with past BLS attempts to survey construction laborers workers about their injuries (1986), these carpenters were quick to accept responsibilities for their injuries – even when it appeared the injury may have been caused by others or involved multiple-factors. Lack of awareness of on-site safety programs was associated with less time on the site and working for the contractor. This finding is unlikely to be due to biased reporting from injured workers in light of their acceptance of responsibility and the associations with time on site and experience with the contractor.

Limitations and Strengths

We know we did not get full reporting of injuries among participating contractors. The rates we report from the active surveillance are considerably lower than those we calculated from the self-insured contractors compensation records including time largely before the active surveillance effort. Their records were not limited to OSHA recordables and their injury rates were declining significantly during the six years for which we had data. However, we still recognize the likelihood that a number of injuries were never reported for investigation. At times absence of staff responsible for reporting injuries resulted in late or under-reporting. There likely was also some failure to report due to inconvenience, or not wanting to report, and the latter particularly could create bias. One large drywall contractor chose to ask all workers if they wanted to participate before reporting any injuries. Obviously, no information was available about injuries the carpenter chose not to report as work-related. No information was available on exposures of

the uninjured members of the cohort and thus, injury rates could not be calculated by exposure to specific tasks or tools.

Since this was an entirely union workforce, questions arise as to whether the experience of union carpenters is generalizable to a non-union environment. Union carpenters receive training through established apprenticeship programs. They also might be less likely to report injuries since they have other insurance coverage through the union. Davis et al. (2001), reported that union workers are more likely to report musculoskeletal disorders earlier; however, few of these were seen. The project was conducted with predominantly large contractors (hiring a mean of 80 full-time carpenters per year) who may have more resources for health and safety than smaller contractors. Higher rates may have been seen under different circumstances.

Rapid evaluation is difficult to achieve even under these circumstances, and this level of surveillance is time consuming. The interviews with injured workers took a minimum of 20 minutes to complete. Much of the interview involved closed ended questions based on knowledge from earlier analyses of compensation records. However, it was felt to be important to understand in detail the circumstances surrounding injuries among this group of workers who are difficult to study, resulting in open ended items and text data with which to deal. An OSHA reportable definition was used for this project to ease the administrative burden on participating contractors and to capture a fuller understanding of all injuries. To decrease costs involved, a threshold for data collection could be established.

The only information available on the injuries came from interviews with workers done shortly after injury. While this provided some idea about severity, particularly for devastating events, severity can be difficult to quantify at this early stage. Better severity measures could be particularly useful in trying to

establish priorities for prevention. The data from the self-insured homebuilders provided some data on severity that, while not matching the exact dates of the active surveillance, were still quite useful.

Despite these limitations, there are also a number of strengths to this approach. High participation rates among injured workers are likely a reflection of the investigations having been done by fellow union carpenters, who have in-depth knowledge of situations encountered in the field and were able to quickly establish rapport with the injured carpenters. These data come directly from injured workers - a perspective that is important, not just in understanding events, but in planning interventions. At the outset there was concern that the process would lead to blaming of contractors. Patterns are not suggestive of this and, in fact, workers were quite willing to take responsibility for their own injuries – even at times when the trained investigators felt there were other explanations for the events. They reported circumstances when the contractor bore some responsibility, but this was, by no means, across the board.

Conclusions

This project utilized a combination of active injury reporting and surveillance with passive surveillance involving analyses of existing workers' compensation records. The latter provided access to information on cost of injuries which was useful in establishing prevention priorities. These data provide information that allowed the identification of rare but more serious injuries which should be targets for prevention. The hours worked provided by the union were particularly useful in allowing rate-based analyses that could document differences in risk between apprentices and journeymen carpenters. Lastly, the focus group information provided qualitative data that helped contextualize the work of these carpenters, giving us insight into exposure differences by union status, risk perception, and safety practices.

Active surveillance yields information on factors that contribute to injuries among high risk construction workers who are difficult to study for practical reasons. The approach of collecting data on injuries, and the injured individuals, as they occur, provides the opportunity to later compare different types of injuries on variables collected from all of the injured population at the time of injury. This avoids the problem of recall bias which is typically of concern in other case-control analyses. Unfortunately in this project the sample size was too small for the planned analyses on back injuries. The process is more time consuming than passive surveillance activities, but the information is more useful for understanding the circumstances surrounding injuries and in formulation of concrete preventive recommendations. Collaboration with the union, and participating contractors, provided venues for sharing of findings. The rapid feedback to those "who need to know" from the Centers for Disease Control and Prevention surveillance definition (1987) is more likely to occur in a meaningful manner through this type of collaborative activity.

Acknowledgments

The investigators want to acknowledge Terry Nelson, Executive Secretary-Treasurer of the Carpenters District Council of Greater St. Louis and Vicinity; Patrick Sullivan, Executive Vice President of the Home Builders Association of Greater St. Louis; and John S. Gaal, Coordinator, Saint Louis Carpenters Joint Apprenticeship Committee for their support, recruitment of contractors and investigators, and guidance. We wish to thank Ron Laudel, Benefits Plan Administrator, Carpenters' District Council of Greater St. Louis for providing regular updates of the cohort and hours worked, and all participating contractors, and their staff, who reported injuries to the project office.

We acknowledge the contributions of Robert Behlman (Behlman Builders) and Dale Klatt from Cannon-Cochran Management Company for providing data for analyses. We acknowledge the roles of Mark Fuchs from the Joint Apprenticeship Committee and Don Rouse from Whitaker Homes for insight and interest in prevention of injuries from pneumatic tools.

Gratitude is expressed to Betty Bazile at the Carpenters District Council for management of the injury reports, notification of the investigators and support for innumerable things along the way. We also want to thank Kristy White at the Carpenters' District Council for supporting dissemination of information through the *Cutting Edge*, for photography assistance, and recruitment of carpenters for focus groups.

We acknowledge the role of Kristie Wicker in the Department of Occupational and Environmental Medicine at Duke University Medical Center for support throughout the project.

Finally, and most importantly, we acknowledge the injured carpenters of the Carpenters District Council of Greater St. Louis who provided information about their experiences and injuries in an effort to prevent injuries among their peers.

DISSEMINATION

Presentations

Academic

Sorock G, Fathallah F, Burdorf A, Collins J, Lipscomb HJ, Reeve G. Panel: The Role of Epidemiological Studies in Ergonomics Research. (Lipscomb): Acute Injury vs. Cumulative Disorder or Disease Process? How Conceptualization of the Problem Drives Measurements of Exposure. Joint Meeting of Human Factors and Ergonomic Society and International Ergonomics Association, San Diego, California, August 2000.

Lipscomb HJ, Dement JM, Li Leiming, Nolan J, Patterson D. Work-related falls in residential and drywall construction. National Occupational Injury Research Symposium, National Institute for Occupational Safety and Health, Pittsburgh, Pa. October 2000.

Dement JM, Lipscomb HJ, Li Leiming, Nolan J, Patterson D. Nail gun injuries in construction: Needs for gun control measures? National Occupational Injury Research Symposium, National Institute for Occupational Safety and Health, Pittsburgh, Pa. October 2000.

Active Injury Surveillance in Carpentry. St Louis University School of Public Health and University of Missouri Labor Education Program. Health and Safety Conference. Workers' Memorial Day, St. Louis, Missouri, May 2001.

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D. The utility of combined passive and active surveillance to establish intervention priorities in residential construction. EPICOH 2001. Fifteenth Symposium on Epidemiology in Occupational Health, Copenhagen, Denmark. August 2001.

Lipscomb HJ, Dement JM, Cameron W, Nolan J, Patterson D. The importance of the context of work in understanding patterns of injury risk by union status among residential carpenters. 16th EPICOH Congress on Epidemiology in Occupational Health. Barcelona, Spain. (September 2002)

Construction and Safety Audiences

Injury Prevention Among Union Carpenters. St Louis University School of Public Health and University of Missouri Labor Education Program. Health and Safety Conference Workers' Memorial Day, St. Louis, Missouri, April 2000.

Falls in residential carpentry. Making Science Work for You: A Symposium for Safety Practitioners. National Safety Council Congress and Expo. Atlanta, Georgia. September 2001.

Nail Guns. Making Science Work for You: A Symposium for Safety Practitioners. National Safety Council Congress and Expo. Atlanta, Georgia. September 2001.

St. Louis Injury Prevention Project. St Louis University School of Public Health and University of Missouri Labor Education Program. Health and Safety Conference. Workers' Memorial Day, St. Louis, Missouri, May 2002.

Lipscomb HJ, Dement JM, Nolan J, Patterson D, Fuchs M, Rouse D, Heinlen C, Hutchinson L. Roundtable presentation: Understanding and preventing injuries from pneumatic nail guns. 12th Annual Construction Safety and Health Conference and Exposition, May 2002.

Lipscomb HJ, Nolan J, Patterson D. Presentation to construction trade students, Rankin Technical College, St Louis Missourri. Fall 2001.

Lipscomb HJ. Presentation to St. Louis Homebuilders Self-insured Workers' Compensation group, Sept 2002. Results of data analyses of self-inured funds over 6 year period and SLIPP results.

Nolan J, Patterson D. Injury Patterns and Prevention. Piledrivers and Shops and Mills Local.

Publications

Academic

In press

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D.
Descriptive Epidemiology of Work-related Injuries in Residential and Drywall Carpentry from Active Injury Surveillance.
In press Applied Occupational and Environmental Hygiene (December 2002)

Dement JM, Lipscomb H, Li Leiming, Epling C, Desai T.
Surveillance of Nail Gun Injuries Among Construction Workers.
In press Applied Occupational and Environmental Hygiene (November 2002)

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D.
Nail Gun Injuries in Residential Carpentry: Lessons from Active Surveillance.
In press Injury Prevention (November 2002)

In internal review now

Lipscomb HJ, Dement JM, Li L, Nolan J, Patterson D.
Falls in Residential Carpentry and Drywall Installation: Findings from Active Injury Surveillance.
Planned submission to: *Journal of Occupational and Environmental Medicine*

Lipscomb HJ, Dement JM, Behlman R, Sullivan P
Patterns of work-related injuries among residential carpenters, 1995-2000
Planned submission to: *Journal of Occupational and Environmental Medicine*

Lipscomb HJ, Dement JM, Mirka G. Back injuries in residential and drywall carpentry.
Planned submission to: undecided

Union and trade publications
Published
Article series in *Cutting Edge*, official newsletter of the Carpenters District Council of Greater St. Louis and Southern Illinois
List articles

Carpenter Magazine - Official publication of the United Brotherhood of Carpenters and Joiners of North America
Title

Builders News - Official publication of Homebuilders Association of Greater St. Louis

WEB Site
Carpenters' District Council of Greater St. Louis
Summary findings located at: http://www.carpdc.org/slipp

REFERENCES CITED

Adams, M and Dolan, P, (1995), "Recent Advances in Lumbar Spinal Mechanics and their Clinical Significance", Clinical Biomechanics, 10(1): 3-19.

Albericco G, Bucci I, Ciarelli F, *et al.* An unusual case of nail gun injury: penetrating neck wound with nail retention in the right pleural cavity. J Trauma;43(1) 153-156, 1997.

Andersson GBJ. Epidemiologic aspects on low-back pain in industry. Spine 6(1):53-60, 1981.

Andersson GBJ, Pope M, Frymoyer J. Epidemiology, in POPE M, Frymoyer J, Andersson GBJ (eds): Occupational Low Back Pain. New York, Prager Publishers: 104-114, 1984.

Arnold R, Guertin M. Framing with nail guns. Fine Homebuilding. ;74-80,June/July 1999.

Baggs J, Cohen M, Kalat J, *et al.*. Pneumatic Nailer ("Nail Gun") Injuries in Washington State, 1990-1998, Safety and Health Assessment and Research for Prevention (SHARP) Program. Washington State Department of Labor and Industries, Technical Report Number:59-1-1999.

Baggs J, Cohen M, Kalat J, et al.. Pneumatic Nailer Injuries: A Report on Washington State 1990-1998, *Professional Safety Magazine,* January 2001 .

Baker S. Children in motor vehicles. Never too young to die. JAMA 242(26):2848-51, Dec 28, 1979.

Baldwin M, Johnson WG, Hogg-Johnson SA. The error of using return-to-work to measure outcomes of health care. Amer J Indus med 29(6):632-641, 1996.

Beer, F. and Johnston, E., (1988), Vector Mechanics for Engineers, McGraw-Hill, Fifth Edition.

Bernold, L and Guler, N, (1993), "Analysis of Back Injuries in Construction", Journal of Construction Engineering and Management, 119(3): 607-621.

Berquist-Uhlmann M, Larsson U. Acute low back pain in industry - a controlled prospective study with special reference to therapy and confounding factors. Acta Orthop Scand (Suppl) 170, 1977.

Biering-Sorensen F. A prospective study of low back pain in the general population. I. Occurrence, recurrence, and aetiology. Scand J Rehab Med 15: 71-79,1983.

Bruno JR, Levin LM, Stanton DC. Pneumatic nail gun injury to the maxillofacial region: case report. J Trauma;45(2):410-412, 1998.

Building and Construction Trades Department, AFL-CIO. Comments concerning residential construction submitted to the ACCSH working group, (unpublished data), February, 1997.

Carey T. Care-seeking among individuals with chronic low back pain. Spine 20(3): 312-317, 1995.

Cattledge GH, Schneiderman A, Stamevich R, et al. Non-fatal occupational fall injuries in the West Virginia Construction Industry. Acid Anal Prev 1996;28(5):655-63.

Cats-Baril, Frymoyer J. Demographic factors associated with the prevalence of disability in the general population, analysis of NHANES I database. From Symposium: Research methods in occupational low back pain. Spine 16(6):671-674, 1989.

Chaffin, D., (1974), "Human Strength Capability and Low-Back Pain," Journal of Occupational Medicine, 16, 248-254.

Chaffin, D. and Park, K., (1973), "A Longitudinal Study of Low-Back Pain as Associated with Occupational Weight Lifting Factors," American Industrial Hygiene Association Journal, 34, 513-524.

Chaffin, D., and Erig, M., (1991), "Three-Dimensional Biomechanical Static Strength Prediction Model Sensitivity to Postural and Anthropometric Inaccuracies," IIE Transactions, 23(3): 215-226.

Charmas SE. Nailing down the nail gun case (Safe at Home and At Work). Trial 1996;32(8):30-34.

Cheadle A, Franklin G, Wolfhagen C, Savarino J, Lui PY, Salley C, Weaver M. Factors influencing the duration of work-related disability: a population based study of Washington State workers' compensation. AJPH 84(2):190-196, 1994.

Chiou SS, Pan CS, Fosbroke DE. Identification of risk factors associated with traumatic injury among drywall installers. Advances in Occupational Ergonomics and Safety II. Edited by Biman dasa and Waldemar Karwowski. IOS Press and Ohmsha, p 377-380, 1997.

Damkot DK, Pope MH, Lord J, Frymoyer JW. The relationship between work history, work environment and low-back pain in men. Spine 9(4):395-399, 1984.

Davis L.; Wellman H.; Punnett L.: Surveillance of Work-Related Carpal Tunnel Syndrome in Massachusetts, 1992-1997: A Report from the Massachusetts Sentinel Event Notification System for Occupational Risks (SENSOR). Am J Ind Med 39(1):58-71, 2001.

Dement JM, Lipscomb HJ. Workers' compensation experience of N.C. residential construction workers, 1986-1994. Applied Occupational and Environmental Hygiene, 14:97-106,1999.

Dement JM, Lipscomb HJ, Li L, et al. Surveillance of nail gun injuries among construction workers. Appl Occup Environ Hyg 2003 *(in press, May 2003).*

Engineering News Record. Third Quarterly Cost Report. Insurance: benefits are an issue as rates stabilize. p32-33, September 29, 1997.

Frymoyer JW, Pope MH, Clements JH, Wilder DG, et al. Risk factors in low-back pain. JBJS 65-A(2):213-218, 1983.

Glazner J.E.; Borgerding J.A.; Lowerey J.T.; et al.: Construction Injury Rates May Exceed National Estimates: Evidence from the Construction of Denver International Airport. Am J Ind Med 34:105-112 (1998).

Haenszel W.; Loveland D.; Sirken M.: Lung-Cancer Mortality as Related to Residence and Smoking Histories. J Natl Cancer Inst. Appendix C:1000 (1962).

Higgins DN, Casini VJ, Bost P, Johnson W, Rautianen R. The Fatality Assessment and Control Evaluation program's role in prevention of occupational fatalities. Inj Prev 2001;7(Suppll):i27-33.

Holmstrom EB, Lindell J, Moritz U. Low back and neck/shoulder pain in construction workers: Occupational workload and psychosocial risk factors. Spine 17(6):663-671, 1992.

Jacobsson L, Lingarde F, Manthrope R, Ohlsson K. Effect of education, occupation and some lifestyle factors on common rheumatic complaints in a Swedish group aged 50-70 years. Annals Rheum Dis 51:835-843, 1992.

Jithoo R, Govender ST, Nathoo N. Penetrating nail gun injury of the head and chest with incidental pericallosal artery anerysm. S Afr Med J;91(4):316-317,2001

Kelsey JL, Golden AL, Mundt DJ. Epidemiology of Rheumatic Disease. Low back pain/prolapsed lumbar intervertebral disc. Rhem Dis Clin NA 16(3):699-136, 1990.

Kisner SM, Fosbroke DE. Injury hazards in the construction industry. J Occup Med 36(2):137-43, 1994.

Kizer KW, Boone HA, Heneveld E, et al. Nail gun injury to the heart. J Trauma 1995;38(3):382-383. Kenny N, O'Donaghue D, Haines J. Nail gun injuries. J Trauma;35(6):943-945,1993.

Lavender, S., Oleske, D., Nicholson, L., Andersson, G., and Hahn, J., (1999) "Comparison of Five Methods Used to Determine Low Back Disorder Risk in a Manufacturing Environment," Spine, 24, 1441-1448.

Lipscomb HJ. Effectiveness of Interventions to prevent work-related eye injuries. Amer J Prev Med;18(4S): 27-32,2000.

Lipscomb HJ, Dement JM, Loomis DP, Silverstein B, Kalat J. Surveillance of work-related musculoskeletal injuries among union carpenters. Amer J Indus Med 32: 629-640, 1997.

Lipscomb HJ, Kalat J, Dement JM. Workers' compensation claims of union carpenters 1989-1992: Washington State. Appl Occup Environ Hyg 11(1):56-63, 1996.

Lipscomb H.J.; Dement J.M.; Li L.; et al.: The Utility of Combined Passive and Active Surveillance to Establish Intervention Priorities in Residential Construction. Int J Occup Environ Health 7(3): S24 (2001).

Lipscomb HJ, Dement JM, McDougall V, Kalat J. Work-related eye injuries among union carpenters. Appl Occup Environ Hyg;14(10): 665-676,1999.

Marras, W., Lavender, S., Leurgans, S., Rajulu, S., Alread, G. Fathallah, F. and Ferguson, S., (1993) "The Role of Dynamic Three-Dimensional Trunk Motion in Occupationally Related Low Back Disorders: The Effects of Workplace Factors, Trunk Position and Trunk Motion Characteristics on Risk of Injury," Spine, 18, 617-628.

Marras, W., Lavender, S., Leurgans, S., Fathallah, F., Ferguson, S., Allread, G., and Rajulu, S., (1995), "Biomechanical Risk Factors for Occupationally Related Low Back Disorders," Ergonomics, 38, 377-410.

McGill, S., (1997), The Biomechanics of Low Back Injury: Implications on Current Practice in Industry and the Clinic," Journal of Biomechanics, 30(5): 465-476.

McVittie D. Fatalities and serious injures. Occup Med 10(2):285-93, 1995.

Magora A. Investigation of the relation between low back pain and occupation. Indus Med 39(11):465-471, 1970.

Microsoft ACCESS 97 [computer program]. Version 4.0: Microsoft, 1997.

Mirka, G., Kelaher, D., Nay, T., and Lawrence, B., (2000), "Continuous Assessment of Back Stress (CABS): A New Method to Quantify Low-Back Stress in Jobs with Variable Biomechanical Demands," Human Factors, 42(2): 209-225.

Morbidity and Mortality Weekly Report. Fatal Occupational Injuries in the U.S, 1980-1994. April 28, 1998.

National Institute for Occupational Safety and Health, (1981), Work Practices Guide For Manual Lifting, DHHS (NIOSH) Publication No 81-122.

Nelson T. Executive Secretary/Treasurer St. Louis District Council, United Brotherhood of Carpenters and Joiners (personal communication). May, 1998.

Nobel JL, Wing PC. Pneumatic nail gun injuries to the knee. Clin Orthop;217:228-229, 1987.

Pope MH. Concepts in prevention of low back pain. Cont Ortho 17(3);43-54, 1988.

Pope MH, Andersson GBJ, Chaffin DB. The workplace, in Occupational Low Back Pain, eds Pope MH, Andersson GBJ, Frymoyer JM, Chaffin BD. CV Mosby, St. Louis, Mo. 117-131, 1991.

Pollack ES, Keimig D. Counting illnesses and injuries in the workplace: proposals for a better system. National Academy of Sciences, Washington, D.C. , 1987.

QSR International Pty, Ltd, 2000.

Robertson LS. Injury Epidemiology, p11. Oxford University Press, 1992.

Robinson JC. The rising long-term trend in occupational injury rates. AJPH 78(3):276-281, 1988.

Rossignol M, Suissa S, Abenhaim L. The evaluation of compensated occupational spinal injuries; a three-tear follow-up study. Spine 17(():1043-1047, 1992.

Ryden LA, Molgaard CA, Bobbitt SL. Benefits of a back care and light duty health promotion program in a hospital setting. J Community Health 13 94): 222-230, 1988.

Salminen ST. Epidemiological analysis of serious occupational accidents in southern Finland. Scand J Soc Med 22(3):225-7, 1994.

SAS Institute, Inc.: The SAS System, Version 8.0. SAS Institute, Inc., Cary, N.C.(1999).

Schneider S, Susie P. Ergonomics and construction: a review of potential hazards in new construction. Am Ind Hyg Assoc J 55:131, 1994.

Smith GS. Public health approaches to occupational injury prevention: do they work? Inj Prev 2001; 7(Suppl 1): i3-10.

Snook S, Jensen R. Cost. In Pope, Frymoyer, Andersson (eds): Occupational Low Back pain. New York, Prager: 115-121, 1984.

Sorock GS, Smith EO, Goldoft M. Fatal occupational injuries in the New Jersey construction industry, 1983 to 1989. J Occup Med 35(9): 916-921, 1993.

Spengler DM, Bigos SJ, Martin NA, Zeh J, et al. Back injuries in industry: a retrospective study. I. Overview and cost analysis. Spine 11(3):241-245, 1986.

Spitzer W. Chairman. Scientific approach to the assessment and management of activity related spinal disorders, a monograph for clinicians. Report of the Quebec task force on spinal disorders. Commissioned by Institute for Workers' Health and Safety of Quebec. Diagnosis of the problem. Spine 12 (7S):516-521, 1987.

Stone PW. Traumatic occupational fatalities in South Carolina, 1989-90, Public Health Rep 108(4):483-8, 1993.

Troup JDG, Martin JW, Lloyd CEF. Back pain in industry: a prospective study. Spine 6(1):61-69, 1981.

U.S. Dept of Labor, Bureau of Labor Statistics. Injuries to construction laborers. Bulletin 2252, March 1986.

U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, CDC Comprehensive Plan for Epidemiologic Surveillance. (1987).

US Dept of Labor, Bureau of Labor Statistics: Industry at a Glance, Construction. Available at: wysiwyg://24//http://www.bls.gov/iag/iag.construction.html. (April 25, 2002).

U.S. Department of Labor, Bureau of Labor Statistics. Workplace injuries and illnesses in 1994. USDL-95-508. December 15, 1995.

U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health Publication No. 2000-116; 2000. Worker Deaths by Falls: A summary of Surveillance Findings and Investigative Case Reports.

Volinn E, van Koevering D, loeser J. Back sprain in industry, the role of socioeconomic factors in chronicity. Spine 16(5):542-548, 1991.

Von Korff M. Studying the natural history of back pain. Spine 19(18S):2041S-2046S, 1994.

Waller JA, Payne SR, Skelly JM. Injuries to carpenters. JOM 31(8):687-692, 1989

Waller JA, Payne SR, Skelly JM. Disability, direct cost, and payment issues in injuries involving woodworking and wood-related construction. Acid Anal Prev 22(4):351-360, 1990.

Wang MJ, Chen IS, Tsai SK. Nail gun penetrating injury of the left ventricle and descending aorta. Circulation;100(3):e18-e19,1999.

Wang, M., Garg, A., Chang, Y., Shih, Y., Yeh, W., and Lee, C., (1998), "The Relationship Between Low Back Discomfort Ratings and the NIOSH Lifting Index," Human Factors, 40, 509-515.

Waters, T, Putz-Anderson, V., Garg, A. and Fine, L., (1993) "Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks," Ergonomics, 36, 749-776.

Waters, T., Putz-Anderson, V., and Garg, A., (1994), Applications Manual for the Revised NIOSH Lifting Equation, DHHS (NIOSH) Publication No. 94-110.

Waters, T., Baron, S., Piacitelli, L., Andedrson, V., Skov, T. Haring-Sweeney, M., Wall, D., and Fine, L., (1999) "Evaluation of the Revised NIOSH Lifting Equation: A Cross-Sectional Epidemiologic Study," Spine, 24, 386-394.

Webb Associates, (1978). Anthropometric Source Book, NASA Ref 1024, National Aeronautic and Space Administration.

Webb DP, Ramsey JJ, Dignan RJ, *et al.* Penetrating injury to the heart requiring cardiopulmonary bypass: a case study. J Extra-Corpor Technol;33(4), 249-251, 2001.

Weisel S, Boden SD, Fefer HL. A quality-based protocol for management of musculoskeletal injuries. A ten year prospective outcome study. Clin Orthop. April (301):164-176, 1994.

Wickstrom G, Hanninen K. Determination of sciatica in epidemiologic research. Spine 12(7):692-698, 1987.

Wu WQ, Tham CF, Oon CL. Cranio-cerebral injuries from nail-gun used in the construction Industry. Surg Neurol;3(2):83-88, 1975.

Appendices

A. St. Louis Injury Prevention Project (SLIPP): Injury Investigation Protocol for Worker Interviews Site Visit Checklist (for sites where falls occurred)

B. Focus Group Discussion Guides
Apprentices
Journeymen

C. *Cutting Edge* (carpenter newsletter) articles

D. Carpenter Magazine (Official publication of United Brotherhood of Carpenters and Joiners of North America) Article

Appendix A

St Louis Injury Prevention Project

- Injury Investigation Protocol for Worker Interviews
- Site Visit Checklist (for sites where fall occurred)

G:\scsi2\lipsc005\st_louis\ques_test.wpd 10-19-99

Date reported:_____
Investigator:_____
Code Number: _____

Date and Time for Call Back:_____

St. Louis Injury Prevention Project (SLIPP)

Injury Investigation Protocol for Worker Interviews

Information for Participants in project 'Etiology of Injury in Drywall and Residential Carpentry'

Investigators are to provide possible participants with the following information.

Hello. My name is [YOUR NAME] and I am a carpenter working with the St. Louis Injury Prevention Project. You may have read about this research project in the 'Cutting Edge' newsletter. The United Brotherhood of Carpenters and Joiners and the Carpenters' District Council are working with researchers from Duke University to identify measures to prevent injuries to carpenters who do drywall or residential work.

.

You are being asked to help us with this project. Journeymen carpenters, such as myself, are talking to union carpenters in the St. Louis area who have had injuries on the job, and we are visiting job sites where falls occur. We want to learn what kind of injury you had and how your injury happened. We are also interested in things you think might have prevented the injury from ever happening. Through this research project, carpenters have an opportunity to talk to other carpenters about their injuries.

Please rest assured that:

- Participation is voluntary.
- You can decline participation with no repercussions.
- Any reports resulting from this project will only summarize the information that groups of workers provided. No workers will be identified by name.
- The information you provide is confidential.
- No information will be shared with your employer, union business agents, or workers' compensation insurer.

This study has been given a Certificate of Confidentiality. This means anything you tell us will not have to be given out to anyone, even if a court orders us to do so, unless you say it is okay. The information will be used to help identify causes of injuries and things that might prevent injuries in drywall and residential carpenters. The form I use to record this information only contains a code number and does not include your name. The information you and other carpenters provide will be sent to Duke University where it will be computerized without any personal information, such as your name.

If you have any questions you may call Dr. Hester Lipscomb or Dr. John Dement at Duke University at (919) 286-3232. You may also call Buck Cameron with the Center to Protect Workers' Rights in Seattle, Washington. (206) 935-7748. Any of these calls can be made collect. In addition, you may call the Office of Risk Management at Duke University Medical Center (919) 684-3277 for any questions you may have about your rights as a research subject.

We hope you will help us with this important work. The interview will take about 45 minutes to complete. Do you have any questions or is there any other information I can give you about the project?

Are you willing to participate in the project? ___ No. Alright, thank you for your time.
___ Yes. Great. Is this a convenient time to ask you some questions?

If not a convenient time -- can you tell me a time when it would be convenient for me to call back?
[RECORD DATE AND TIME FOR CALL BACK]

If convenient time ---- then proceed with interview.

INJURY DESCRIPTION

1. I am interested in learning about an injury that you recently sustained on: _____.
Please tell me what kind of injury you had that day.

Interviewer checklist:
Body parts injured ___
Nature of injuries ___
Time lost ____

List all body parts injured the nature of each injury : [examples: Back sprain, hand cut, broke hand scratched eye].

2. Tell me about how the injury happened and what you were doing when you got hurt.

Interviewer checklist:
What happened ___

Type of injury ___
(fall, struck by, etc)

Task at time ___

Other factors ____

PROMPT After description -----> Were there any particular things that you think led to the injury?

3. What tools or equipment were you working with at the time of the injury? (list all)

Equipment	Any malfunction?	If Yes, **describe***
_____	No Yes —>	_____ _____ Brand:_____ Age:_____ Maintenance:_____ _____
_____	No Yes —>	_____ _____ Brand:_____ Age:_____ Maintenance:_____ _____
_____	No Yes —>	_____ _____ Brand:_____ Age:_____ Maintenance:_____ _____

(*Describe what happened. Record details of equipment including brand name if known, age of tool, maintenance of tool)

4. Did any tools or equipment contribute to your injury in any other way (other than malfunctioning)?

No ___
Yes___

If yes, what tool or equipment was that? _____

Were safety guards or devices present?
Yes ___
No ___
Describe: _____

Were they used?
Yes ___
No ___
Describe: _____

5. What materials were you working with at the time of the injury?

_____

_____

_____

6. Was the activity you were doing at the time of your injury a NEW or unfamiliar job task?

Yes____
No____

7. How much experience do you have with the specific task you were doing when injured? (Record number)

_____years _____months _____weeks _____days

8. Was the activity you were doing at the time of the injury part of your usual job tasks?
   Yes____ No____

9. Was anyone else also injured?
   Yes____ No ____

10. Were other workers involved at all when you were injured? For example, was the injury the result of working near another worker?
    No _____
    Yes ____
    If YES, what were they doing ?

    _____
    _____
    _____
    _____

    What trade were they? (carpenter, plumber, electrician, mason, etc.)_____

Most common injury mechanisms expected: -------> If none of these Skip to page 13 'JOB SITE'

'Struck by Injuries'
'Caught by or between'
'Something in eye'

Include:
- struck by tool or object
- struck against
- caught against,
- caught by

GO TO PAGE 5

- eye injuries

CONTINUE BELOW

'Overexertion'

Include injuries from:
- lifting
- carrying
- pushing/pulling
- cumulative trauma
- moving
- just starting hurting

'Sprains/strains'
GO TO PAGE 7

'Falls'
PLAN SITE VISIT

Includes any injury from a fall.

Does NOT have to have been from elevation.

Includes trips/slips.

GO TO PAGE 9

If EYE Injury complete question 11 below.

11. Were you wearing eye protection?
    _____ No
    _____ Yes
    If yes, what type of eye protection were you using?
    Regular glasses ___
    Safety glasses with side pieces____
    Safety glasses without side pieces____
    Goggles____
    Other ____ Describe: _____

    How did the eye protection fail? _____
    _____

Skip to Page 13 'JOB SITE'

Struck By

Specific information to collect for all 'STRUCK BY OR CAUGHT BY/BETWEEN' injuries

12. With what were you struck or caught? _____

What do you think this object weighed? Think about other things you handle in guessing the weight. For example, a 4' X 8' 3/4 inch sheet of plywood weighs 63 pounds, a nail gun weighs about 8 pounds and an 8 foot length of 2X4 weighs 13 pounds.

Estimated size or weight of object _____ (pounds)

From what distance had the object traveled when it struck you?

Distance object had traveled in feet _____

13. What caused the object or material to strike you?

_____

_____

For **nail gun injuries**

Was there a sequential trigger in place? By this I mean a trigger which would not allow bounce nailing?

____ Yes
____ No

Was the trigger mechanism locked in the firing position? By that I mean was it set so you could " do bounce nailing" ?

____ Yes
____ No

For **injuries from saws**

Was the injury caused by kickback of the material being cut?

____ Yes
____ No

Did the saw have a guard in place?

____ Yes ----- Was it used? Yes___
No ___

____ No

Did the saw have or an anti-kickback mechanism?

____ Yes ----- Was it used? Yes___
No ___

____ No

Skip to page 13 'JOB SITE'

Overexertion

Specific information to collect for all 'OVEREXERTION/BODILY MOTION' injuries
Record information about the task of the carpenter at the time of the injury based on the original description .

14. Tell me more about the exact task you were doing when you got hurt. ***(If there was not a specific task or activity that caused the injury, what does the carpenter think caused the disorder?)***

Activity? (Describe)

_____

_____

Lifting what? _____
From where (ground to carry, from rack 18" off ground)? _____
How were you holding object?_____

Carrying what? _____
How holding object? _____
From where had object been picked up? _____

Pushing what ?_____
On what surface (flooring, ground outside, gravel?) _____
Using assistive device?
No _____
Yes _____
If YES, what type of device? (Dolley, hand truck, etc.)

_____

Pulling what?_____
On what surface (flooring, ground outside, gravel?) _____
Using assistive device?
No _____
Yes _____
If YES, what type of device? (Dolley, hand truck, etc.)

_____

15. Tell me how often you had done this same task?

First, how many times had you done that same task <u>on the day you got hurt</u>?
_____ (number)

How many times had you done that same task <u>the week you got hurt</u>?
_____ (number)

16. What materials were involved (sheetrock, plywood sheet, rebar, etc --length, width, estimate weight)?

Material involved	Size	Estimated weight of object
_____	_____	_____

17. Were you doing the task alone or was any one else helping?
Doing task alone_____
Working with someone else _____

18. Was the load unexpected?

No _____

Yes_____

19. Were you in an awkward posture when you got hurt?

No _____

Yes_____

If yes, describe your position or posture:_____

20. What other tasks had you done that day before you got hurt?

List: _____

Skip to Page 13 'JOB SITE'

Falis

Specific information to collect for all 'FALLS'

21. Did you fall from a height or elevation or did you fall (slip/trip) from the ground or your work surface – by that I mean not from a height?
    ___ fell from height or elevation
    (Skip to FALLS FROM ELEVATION SECTION page 10 - next page)
    ___ did not fall from height or elevation

22. Onto what did you fall? _____
    _____

23. To help us understand the amount of force involved in your fall, about how much do you weigh?
    ____ pounds

24. How did you land when you fell?_____

25. Tell me about the work surface where you were working when you fell. Was it (use all that apply):
    ___ dry
    ___ wet
    ___ frosted/ covered with snow or ice
    ___ damaged or worn surface
    ___ cluttered
    ___ not secure
    ___ HVAC cutouts in floor
    ___ other (describe): _____

26. Did any of the following event(s) precede your fall?
    ___ slipped or tripped (on what): _____
    ___ lost balance
    ___ other: (describe): _____

27. Were you working with any tools at the time of the fall?
    ___ No
    ___ Yes
    If YES, describe: _____

28. Were you handling or carrying any materials at time of fall?
    ____ No
    ____ Yes
    If YES, describe:_____

29. What kind of footwear were you wearing at the time of the fall? _____

30. Could any of the following have contributed to fall:
    ___ work surface slippery
    ___ work surface cluttered
    ___ visibility limited (such as by carrying sheetrock?)
    By what: _____

Skip to Page 13 'JOB SITE'

Specific information on FALLS FROM ELEVATIONS

31. From what did you fall?

___ ladder
___ scaffold What type of scaffold: _____
If using a ladder jack, were the ladders secured at the top end?
___ Yes
___ No
and did the ladders extend 3 feet above the work area?
___ Yes
___ No
___ buckets
___ roof
___ ceiling joist
___ floor joist
___ truss or rafter
___ elevated work surface Describe: _____
___ through an opening Describe: _____
___ other Describe: _____

32. Tell me about the work surface <u>where you were working</u> when you fell. Was it (use all that apply):

___ dry
___ wet
___ frosted /covered with snow or ice
___ damaged or worn surface
___ cluttered/debris
___ guard rails up
___ leading edge marked (6 feet back from edge)
___ not secure or unsteady
___ other (describe): _____

33. Onto what did you fall? _____

34. What was this surface like that you fell onto? Was it...

___ dry
___ wet
___ frosted/ covered with snow or ice
___ damaged or worn surface
___ cluttered
___ other (describe): _____

35. How did you land when you fell?_____

36. How far do you think you fell (in feet)? _____ estimated in feet

37. To help us understand the amount of force involved in your fall, about how much do you weigh?
_____ pounds

38. Did any of the following event(s) precede your fall?
___ work surface collapsed
___ slipped or tripped
___ lost balance
___ equipment failure
___ other: describe _____

39. Were you working with any tools at the time of the fall?
___ No
___ Yes
If YES, describe: _____

40. Were you handling any materials at time of fall?
___ No
___ Yes
If YES, describe:_____

41. Was there any equipment failure involved in your fall?
___ No
___ Yes

If yes, what equipment failed?
___ scaffold planking broke or collapsed
___ scaffolding collapsed
___ scaffolding tipped over
___ ladder slipped
___ ladder broke
___ fall protection failure
___ other / Describe: _____

42. Was there any fall protection available on site?
____ No
____ Yes
If YES, check all that apply:
___ lifeline
___ lanyard
___ harness
___ safety belt
___ net
___ straps
___ ladder cage
___ handrails
___ guardrails
___ roofer sharing line
___ other: (describe)_____

43. Were you using any fall protection at the time of your fall?

___ No
___ Yes
If YES, describe:_____

44. Was there any fall hazard warning at the site? For example were there: (check all that apply)

___ lines
___ signs
___ perimeter barriers
___ no warning
___ other : (describe) _____

45. What kind of footwear were you wearing at the time of the fall: _____

46. What condition was your footwear in? By that I mean was it wet, muddy, etc?

_____

47. Do you think any of the following have contributed to your fall:

___ non-use of fall protection
___ equipment malfunction
___ improper use of fall protection

Continue on Next Page 'JOB SITE'

Job Site

JOB SITE INFORMATION

48. What type of project were you working on when you were injured?
    - ___ Residential Single Family
    - ___ Residential Multi-family
    - ___ Commercial
    - ___ Other
      Describe: _____

49. What was the stage of the construction project?
    - ___ Residential stages groundbreaking / building layout
    - ___ Residential foundation
    - ___ Residential framing 1st story
    - ___ Residential framing 2nd story
    - ___ Residential roofing
    - ___ Residential interior finish, other than drywall
    - ___ Residential exterior finish 1st story
    - ___ Residential exterior finish 2nd story
    - ___ Residential drywall
    - ___ Commercial interior finish (e.g., commercial drywall)
    - ___ Other
      Describe: _____

50. Where on site were you injured?
    - ___ inside building structure
    - ___ outside working on building structure
    - ___ outside surrounding building
    - ___ other
      Describe: _____

51. How long had you been working at that site before your injury?
    ____Days

52. How long had you worked for that contractor, or company, when you got hurt?
    - ____ Days
    - ____ Weeks
    - ____ Months

53. How many workers would you estimate were on your work site including all trades? By this I mean the exact site where you were working (not the subdivision for instance).
    Estimated number of workers on site all trades: _____

54. How many carpenters were on that site: _____

55. What were your responsibilities on this job site?
    _____

56. What was the weather like the day of your injury?_____

57. What about the day before or recently? _____

58. Were you aware of any on-site safety program?

___ No
___ Yes
If YES:
describe what you know about program: _____
_____

Specifically do you know if there was...
____ a safety manual
____ fall protection plan on site
____ hazard communication
____ a designated safety person, by that I mean a person in charge of safety

59. Was site specific safety training given for that site?

___ No
___ Yes, describe: (tool box talks, etc. _____).
If tool box talks, how often did they occur?
___ weekly
___ monthly
___ other : _____

60. Were any of the following examples of personal protective equipment available on site?

	Available	Check if using when injured	
Hard hat	_____	_____	
Gloves	_____	_____	
Safety glasses or goggles	_____	_____	
Ear plugs or other hearing protection	_____	_____	
Safety belt/harness and/or lifeline (With appropriate anchor)	_____	_____	*(define appropriate anchor)*
Safety belt not tied off	_____	_____	
Guardrails or safety railings	_____	_____	
Seat belt (if drive vehicle)	_____	_____	
Aprons	_____	_____	
Back belts	_____	_____	

61. Was there any other personal protective equipment on site that I did not list?

___ No
___ Yes
Describe: _____

62. Was there a designated area for debris? (Pinned in or fenced off area or dumpster)
Yes ____ No _____

How often did cleanup occur or were materials moved to trash area? _____
Who was responsible for cleanup? _____
Was there any policy about it? Y es___ No____
If yes, describe: _____

PERSONAL INFORMATION

Tell me a little bit about yourself .

63. *What is sex of worker?* *Male* _____ *Female* ____

64. What is your age ? _____ (years)

Now tell me some about your experience in the carpenters' union.

65. When did you join the union?
Date joined union ____/____ (MM/YY)
When did you become a journeyman: ____/____ (MM/YY)
_____ currently an apprentice **(Skip to Question #67 below)**

66. Did you go through an apprenticeship program?
___No **(skip to NEXT QUESTION)**
___Yes
If yes,
Apprenticeship began: ____/____ (MM/YY)
ended: ____/____ (MM/YY)

67. Is carpentry your usual occupation?
____ No
If No, what is usual occupation?_____
____ Yes
If Yes, is this your usual type of carpentry work?
____ Yes
____ No

68. How many hours per year would you estimate that you worked in construction in last 10 years?
_____ (hours per year)

69. Tell me about the hours you have worked recently:
Hours worked day of injury before got hurt _____
Hours worked in week before injury _____
Hours worked in month before injury _____
Hours worked in last year _____

70. Tell me about safety training you have had (Check all that apply)

Time since most recent training

___ Safety training in apprenticeship training----------> _____
___ OSHA 10 hour ----------> _____
___ Red Cross Safety Training----------> _____
___ Fall protection----------> _____
___ Body mechanics/ ergonomics----------> _____
(how to lift/carry things safely,
how to work putting less strain on your body)
___ other:
List/describe :_____ -- ----------> _____
_____ ----------> _____
_____ ----------> _____

INJURED WORKER'S ASSESSMENT OF CAUSES OF INJURY AND WHAT COULD HAVE PREVENTED INJURY.

71. Were there any worksite conditions which you feel contributed to your injury? For example did any of the following contribute to your injury? (Check all that apply)

_____Weather
_____ Slippery surfaces
_____ Lighting
_____ Housekeeping or cluttered work areas
_____ Time pressures
_____ Location or delivery of materials
_____ Storage of materials
_____ Others:
Describe:_____

72. Any other factors that contributed to your injury? (Check all that apply)

_____ Co-worker's activity
_____ Speed of work
_____ Wrong tools for job
_____ Fatigue
_____ Task too heavy
_____ Needed training
Describe what training would have been helpful:
_____
_____ Needed help that was not available
Describe help that would have been useful:
_____

73. What might have been different that would have prevented your injury? Or thinking about someone else in the same situation, how could this type of injury be prevented?
(If response is self-blaming such as 'be more careful' or 'lift properly' encourage more specifics and other options that could have prevented the event)

If the carpenter has a back injury proceed with remaining questions.
Otherwise skip to WRAP UP on page 25.

BACK INJURIES

Back injuries or problems are one of the most common work injuries in construction. Because of this we are trying to learn more about these injuries in particular.

74. Did your injury require medical treatment beyond first aid received at the site?
    No ____
    Yes ____
    If YES, where were you treated?
    _____ physician's office /chiropractor's office
    _____ urgent care center
    _____ emergency room
    _____ hospitalized

75. How soon after your injury were you first seen for medical treatment beyond first aid?
    _____ Hours

76. What did the physician or caregiver say was the problem or nature of your injuries? *(Diagnoses)*
    _____
    _____

77. Have you returned to work since your injury?
    No ___
    Yes ___

    If YES, when returned? ___/___/___ MM/DD/YY

78. Are you doing regular, full-duty tasks?
    Yes_____
    No_____
    If NO, what are you doing and how is that different from your regular duties?
    _____
    _____
    If NO, could you do any work on site if you had modified duty?
    No ____
    Yes____
    If YES, what could you do ?
    _____
    _____

I want to ask you some questions about back problems you may have had in the past and your general health as well. Sometimes people are concerned that this information might influence their work or compensation claim. I want to reassure you again that all the information you provide is entirely confidential and is being used only to try to understand back problems in construction better.

79. Have you ever had back problems before?
    No ____
    Yes ____
    If Yes,
    Was the problem bad enough that it restricted your activity at home or at work?
    Yes___
    No____

Did you have to seek medical care for back problems in the past?
Yes____
No____

Did you ever have to have back surgery?
Yes____
No____

80. Do you have any other medical conditions that limit your activities at home or at work?
No ____
Yes__
If YES, what are these problems? _____
_____

I am interested in learning more about the kind of work you have done in the past.
Tell me a little more about your apprenticeship. **(If no apprenticeship skip to #87 NEXT PAGE)**

81. What size contractor did (do) you work for during your apprenticeship? Would you say the contractor hired:
____ under 25 carpenters or
____ 25 or more carpenters?

82. What kind of work did (do) you do in your apprenticeship? (Check all that apply)
___ drywall
___ residential
___ commercial
___ concrete forms
___ driving pile
___ flooring
___ interior systems
___ cabinet makers
___ other list: _____

83. How long did you pack lumber as an apprentice? ____ months

84. How long did you 'hump' drywall as an apprentice? By that I mean how long were you hauling drywall? ____ months

How long did you hang drywall as an apprentice? _____ months

85. During your apprenticeship:
____ did you build from the ground up, or
____ did you work on specialized crews, or
____ both?

86. During your apprenticeship what percentage of your time do you think you have spent doing :
Note: Should add up to 100%

Type of work	**Estimated % of time**
Residential, rough	
Residential, finish (facia, soffits, interior)	
Commercial, rough	
Commercial, finish	
Other, describe	

87. As a journeyman what kind of work have you done? (Check all that apply)
___ concrete forms
___ driving pile
___ drywall
___ residential
___ commercial
___ flooring
___ cabinet makers
___ interior systems
___ other list: _____

88. As a journeyman what percentage of your time do you think you have spent doing :
Note: Should add up to 100%

Type of work	**Estimated % of time**
Residential, rough	
Residential, finish (facia, soffits, interior)	
Commercial, rough	
Commercial, finish	
Other, describe	

89. Are you currently working as a : (check any that apply)
____ Foreman
____ Superintendent
____ General foreman?
If yes, for how long have you been in that job? _____ months

90. Have you ever worked as :

Foreman on site?

__No

__Yes

If yes, about what percentage of your work time in the last 10 years was spent as a foreman? ____%

Superintendent ?

__No

__Yes

If yes, about what percentage of your work time in the last 10 years was spent as a superintendent?____%

General foreman?

__No

__Yes

If yes, about what percentage of your work time in the last 10 years was spent as a general foreman?____%

Non-Union construction jobs

Now I want to ask a little about non-union construction jobs you may have had.

91. Have you worked on non-union construction jobs in the last 10 years?

___No **If no, skip to Question 92 on PAGE 23 (next page).**

___Yes

If yes, can you describe those and when you did them? I am not concerned about every site you worked on, but the kind of work you may have done. Start with your most recent non-union construction job in the in the last 10 years.

Prompt after each response – was there any other non-union construction job in the last 10 years?

Type of construction (residential, drywall, commercial)	MM/YY started	MM/YY ended
Type of construction (residential, drywall, commercial)	MM/YY started	MM/YY ended
Type of construction (residential, drywall, commercial)	MM/YY started	MM/YY ended
Type of construction (residential, drywall, commercial)	MM/YY started	MM/YY ended
Type of construction (residential, drywall, commercial)	MM/YY started	MM/YY ended

Non-construction jobs *(last 10 years)*

Now I want to get some information from you about any non construction work you have done in the past .

92. Over the last 10 years have you held any jobs for more than 3 months that were not in the construction field.

___ No **Skip to WRAP UP on Page 24.**

___ Yes

93. Tell me about those (that) job(s). Start with the most recent non-construction job you had. What was that job and when did you start and stop that work?

Job title or description	MM/YY started	MM/YY ended

Did this job require you to:
____lift or carry more than 25 pounds?
____lift or carry more than 50 pounds?
____twist or bend at the waist frequently?
____work in awkward postures?
____lift repetitively, by that I mean more than 3 lifts per minute

Job title or description	MM/YY started	MM/YY ended

Did this job require you to:
____lift or carry more than 25 pounds?
____lift or carry more than 50 pounds?
____twist or bend at the waist frequently?
____work in awkward postures?
____lift repetitively, by that I mean more than 3 lifts per minute

Job title or description	MM/YY started	MM/YY ended

Did this job require you to:
____lift or carry more than 25 pounds?
____lift or carry more than 50 pounds?
____twist or bend at the waist frequently?
____work in awkward postures?
____lift repetitively, by that I mean more than 3 lifts per minute

Job title or description	MM/YY started	MM/YY ended

Did this job require you to:
____lift or carry more than 25 pounds?
____lift or carry more than 50 pounds?
____twist or bend at the waist frequently?
____work in awkward postures?
____lift repetitively, by that I mean more than 3 lifts per minute

Wrap Up

That is all the questions I have. Is there anything else you would like to tell me about your injury? Or do you have any questions for me?
(Record questions or comments)

Thank you for your help.

INVESTIGATOR ASSESSMENT OF WHAT COULD HAVE PREVENTED INJURY OR CONTRIBUTING FACTORS

(Large free text field)

Time requirements for future planning purposes
Date of interview with worker: ___/___/___ MM/DD/YY
Time required to complete interview _____ : _____ (hours: minutes)

Date of onsite inspection: ___/___/___ MM/DD/YY (leave blank if not done)
Time required for inspection on site: _____ : _____ (hours: minutes)
Time required for travel to and from site:_____ : _____ (hours: minutes)

Participation / cooperation
How well did the carpenter seem to remember and report his/her injury?
___ very well
___ fairly well, some problems
___ not very well

How well did the carpenter seem to remember his/her work history?
___ very well
___ fairly well, some problems
___ not very well

How cooperative was the carpenter?
___ very cooperative
___ fairly cooperative
___ not very cooperative

Other comments of investigator about quality of interview:_____
_____
_____
_____

Investigator : _____

SITE VISITS (revised 5-23-00)

Date: _____ Investigator: _____

Code Number: _____

Foreman or contact person on site: _____

Number of employees on site: ____

Type of construction project: (circle one) Residential single / Residential multi / Commercial / Other_____

Stage of construction: (circle one) Ground breaking / Foundation / Framing 1st floor / Framing 2nd floor / Roofing / Interior finish, not drywall / Exterior finish 1st floor / Exterior finish 2nd floor / Residential drywall / Commercial drywall / Other _____

New construction or remodel/renovate (circle one)

Check all that apply. *N/A=not applicable for current stage of construction project

Conditions Observed	**Yes**	**No**	**N/A***	**Not Observed**	**Comments**
Hard hats used by most?					
Eye protection by most?					
Nail guns have sequential triggers?					
Nail gun use (Finger held on trigger, "bounce nailing")					
Is there a fall protection plan?					
Guards/rails used around openings? (Basement, stairs, windows)					
Slide arresters used on roof?					
Orange paint 6' line of leading edge?					
Ladder jack use limited to 20' high?					
Harness used if ladder jack above 10'?					
Pump jack bracing every 10'?					
Cranes -- tape around swing area?					
Ground fault protection (GFCI)					
Fall protection equipment					
Lifelines					
Lanyards					
Harnesses					
Safety Nets					
Straps					
Ladder Cages					
Handrails					
Roofer sharing line					
Other(describe)_____					

Rate all that apply and comment on condition.

Condition of Site and Equipment	Excel-lent	Good	Fair	Poor	Not Observed	N/A*	Comments
General Site Conditions							
Housekeeping							
Materials Storage							
Access/egress to/from structure							
Backfill around foundations							
Equipment condition	**Acceptable**		**Unacceptable**				
Cords							
Air Compressors/Generators (in safe area, plugged into GFCI, placement)							
Saw guards (in place, sticking)							
Scaffolding (plumb, planks scaffold grade, guardrails if 10ft high, toe board if employees below, planks scaffold grade, check distance from scaffold to face of work)							
Pump jack condition of poles							
Ladders (cleanliness, condition, no job built ladders, 1 ft out for every 1 ft up)							

Other comments:

Assessment of fall that occurred:

Appendix B

Focus Group Discussion Guides

- Apprentices
- Journeymen

Discussion Groups
Carpenter Apprentice Focus Groups

INTRODUCTION: Purpose is to learn more about how you decided to do what you do, and how you get the skills you need. We know apprentices have higher rates of injuries – more so for some types than others - we don't know if that is because of the dangerous of the task or the frequency with which they are assigned these tasks. We want the opportunity to learn from you about your work, things that work well from your perspective and things that you have problems with or that you might change.

ALL CONFIDENTIAL – never report anything with anyone's name attached.

Domain	Questions	Examples/clarification
Introduction	Please introduce yourself (by alias or whatever you want us to call you) and let us know 1) what level of apprentice you are and, 2) any construction experience you may have had before (work in trade, summer job, etc) 3) type of contractor you work for	So just say something like " I am John Smith and I am a first term apprentice, but I worked construction summer jobs since I was 16. I work for a framing contractor (siding, drywall) etc. "
Career decisions	Why did you decide to be a carpenter?	Carpentry is hard work and dangerous work. Why do you want to do it? Family members? Friends? Training in trade before?
	Why did you choose residential work? What sorts of things attracted you to that type of work? Or was it just availability of work?	Residential carpenters make less than commercial carpenters...
	Why did you decide to be a union carpenter? Why did you decide to go through an apprenticeship program?	

Domain	Questions	Examples/clarification
Job site	Tell us about a typical job site.. How many carpenters are you usually working with? Is there always a foreman or supervisor? Is someone assigned to be responsible for safety?	
Progression of tasks/ responsibilities	Tell us about the tasks you are assigned when you were first hired? What do you do when you first go out to job sites.. By that I mean what are the very first tasks you get assigned as the new apprentice? [for those beyond first term: What are the next tasks you get assigned? How do you get progressed to more skilled or more tasks?] How are tasks assigned/divided up on sites among apprentices of different levels and journey men? ?	
	What kinds of jobs are you first assigned?	Do you haul lumber, drywall?
	What tools do you work with at the very first?	Power tools? Nail guns, saws, drills? Specifically what kinds of saws? Etc

Domain	Questions	Examples/clarification
	How do your responsibilities vary by the stage of construction of the project? Foundation work framing roofing interior finish exterior finish ..... or do you usually work at one stage?	
Dangerous task training	We are interested in how you learn to do certain tasks or jobs on sites... and in apprenticeship school? How do you learn how to do things like: • work on top plate? • set trusses? • handle/set steel I-beams? • signal crane? • use nail guns? • operate saws? • work on scaffolding? • work on ladders?	Demonstration, verbal instruction, hands-on training, learn as you go.
	Do you usually feel confident that you know how to do the work you are assigned or do you sometimes feel that you just do the best you can?	

Domain	Questions	Examples/clarification
Supervision/ mentoring	If you don't know how to do something on a job site, can you ask for help? By that I mean are you comfortable asking for assistance ? Who do you ask for help on the job? • Advice or help with task you do not know how to do? • Skill based help	
Safety training	Tell us about your safety training....in apprenticeship training. Have you had fall protection training? What did that consist of?	video class training specific skills like work practices on scaffolding
	What about safety training on job sites –tool box talks? Are you aware of a job site safety plan? Job site fall protection plan? Designated safety person on site?	
	What would you do if you saw something being done that was unsafe on site? What would you do if someone asked you to do something you thought was unsafe?	Nothing, tell co-worker, tell boss? Do it anyway, refuse, ask for help, ask for equipment?
	Do you know how to report a workers' comp injury? Did anybody give you information on this?	

Domain	Questions	Examples/clarification
	Do you usually feel confident that you know how to do the work you are assigned safely or do you feel like you sometimes are taking chances?	
PPE	What kind of personal protective equipment do you use when you work? What is available on the sites on which you work? • hard hat • safety glasses • harnesses, lanyards • hearing protection – plugs Do you have the types of equipment you need?	
Perception of risk	What do you think are the most dangerous task carpenters do? That you are asked to do now?	
Drugs/alcohol	Are there problems with drug or alcohol use on sites?	
School training transfer	Are you able to use the things you learn at the apprenticeship school on job sites?	Some people tell us there are sometimes conflicts with what you are taught and how more seasoned carpenters actually do their work...
Possible Stressors	Are there things you find stressful about your work? Are you ever concerned about safety of tasks you are being assigned? How are newer apprentices treated on job sites? Compared to more seasoned apprentices ? Ct journey men ? Are apprentices valued on the job by journey men?	 told of hazing types of activities supposed to be a brotherhood..

Domain	Questions	Examples/clarification
Suggestions	What would make your job as an apprentice better? How could you learn more? What would make your job safer?	

Discussion Groups
Carpenter Journeymen Focus Groups

INTRODUCTION: Purpose is to learn more about how you work with apprentices on job sites, how you bring them along, what they can and cannot do and how you can tell... We know apprentices have higher rates of injuries – more so for some types than others - we don't know if that is because of the dangerous of the task or the frequency with which they are assigned these tasks.
We want the opportunity to learn from you about your work, things that work well from your perspective and things that you have problems with or that you might change.

ALL CONFIDENTIAL – never report anything with anyone's name attached.

Domain	Questions	Examples/clarification
Introduction	Please introduce yourself (by alias or whatever you want us to call you) and let us know 1) how long you have been a carpenter	So just say something like " I am John Smith and I am have been a carpenter for 14 yrs. "
Job site	Tell us about a typical job site.. How many carpenters are you usually working with? How many of those will be apprentices? What do you see as the role of apprentices? What are they expected to do?	
How ready to work?	How prepared are apprentices to work productively and safety on a site?	
Changes over time	How has this changed over time? Is the ratio similar to what it has been? Is mentoring the same?	

Domain	Questions	Examples/clarification
Progression of tasks/ responsibilities	Tell us about the tasks apprentices get assigned when first hired? What do they do when you first go out to job sites.. By that I mean what are the very first tasks new apprentices might get assigned? Who assigns them those tasks. What are the next tasks assigned? How do they get progressed to more skilled or more tasks? How are tasks assigned/divided up on sites among apprentices of different levels and journey men? ?	
	What kinds of jobs are they assigned first assigned?	Do you haul lumber, drywall?
	What tools do you they work with at the very first?	Power tools? Nail guns, saws, drills? Specifically what kinds of saws? Etc
	How do responsibilities vary by the stage of construction of the project? Foundation work framing roofing interior finish exterior finish ..... or do you usually work at one stage?	

Domain	Questions	Examples/clarification
Dangerous task training	We are interested in how apprentices learn to do certain tasks or jobs on sites... and in apprenticeship school? How do you learn how to do things like: • work on top plate? • set trusses? • handle/set steel I-beams? • signal crane? • use nail guns? • operate saws? • work on scaffolding? • work on ladders?	Demonstration, verbal instruction, hands-on training, learn as you go.
	Do you usually feel confident that you know how to assess what an apprentice is capable of doing? From skill perspective? From safety perspective?	
Supervision/ mentoring	If an apprentice doesn't know how to do something on a job site, who do they ask for help? By that I mean are they comfortable asking for assistance ? Do you like to work with apprentices? How many , at what levels of training , are a good mix on residential sites?	

Domain	Questions	Examples/clarification
Safety training	Tell us about your safety training....in apprenticeship training. Have you had fall protection training? What did that consist of?	video class training specific skills like work practices on scaffolding
	What about safety training on job sites –tool box talks? Are you aware of a job site safety plan? Job site fall protection plan? Designated safety person on site? Who is responsible for the cubs?	
Perception of risk	What do you think are the most dangerous task carpenters do? That you are asked to do now? How do apprentices get safe?	
Drugs/alcohol	Are there problems with drug or alcohol use on sites? Are there more problems among young kids or not? Different problems?	
Possible Stressors	Are there things you find stressful about your work? Are you ever concerned about safety of tasks you are being assigned? How are newer apprentices treated on job sites? Compared to more seasoned apprentices ? Ct journey men ? Are apprentices valued on the job by journey men?	 told of hazing types of activities supposed to be a brotherhood..

Domain	Questions	Examples/clarification
Suggestions	What would make apprentice better? How could you teach or mentor more? What would make your job safer?	

Appendix C

Articles from *The Cutting Edge*

Duke

by Hester Lipscomb, Ph.D., Assistant Research Professor

ST. LOUIS INJURY PREVENTION PROJECT (SLIPP)* NEWS

We are pleased to introduce Denny Patterson, Local 1310; and Jim Nolan, Local 2214, who have been hired by the CDC to work with the St. Louis Injury Prevention Project (SLIPP). Over the next three years, these individuals will be contacting carpenters who have been injured on residential job sites or drywall sites. We want to try to learn more about the injury, and things that might have prevented the injury. The project is unique in using journeymen carpenters, who understand carpentry, to gather information.

Denny Patterson has been in Local 1310 for more than 24 years. Denny is retired, but he used to work for William J. Zickel Company. He has been on the Executive Board of his Local for six years. Denny is also a chair on the Advertising Committee for Local 1310.

Jim Nolan has been in Local 2119 for more than 39 years. Jim has worked commercial and residential carpentry, but currently he's working in residential. He was on the Executive Board of his Local for nine years.

If you do experience an injury at work, we hope you will take the opportunity to tell these brothers about your injury so that we can learn from each other. Strict confidentiality will be maintained. The information you provide will be used only for research purposes and no individuals will be identified in any reports. We hope to make the workplace safer for carpenters through this effort, but we can only accomplish this goal with your help!

(L-R) Jim Nolan, Local 2119; Denny Patterson, Local 1310; Hester Lipscomb, Duke; and Jon Dement, Duke.

** SLIPP is a three year project to identify measures to prevent injuries to carpenters who do residential or drywall work in St. Louis. The project is being undertaken by the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Health and Safety Fund of the United Brotherhood of Carpenters and Joiners, and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH).*

Duke

by Hester Lipscomb, Ph.D. Assistant Research Professor

ST. LOUIS INJURY PREVENTION PROJECT (SLIPP)* GETS UNDERWAY

The St. Louis Injury Prevention Project (SLIPP) will start collecting information from carpenters who experience injuries on residential or drywalling projects this month. Jim Nolan and Denny Patterson, two experienced journeymen carpenters who were introduced in last month's *The Cutting Edge*, will be contacting fellow carpenters shortly after injuries occur. We want to learn more about these events. When injuries occur as the result of a fall, they will also visit the job site. The information they collect will be used to help identify causes of injuries and things that might prevent injuries in drywalling and to residential carpenters. All data will be sent to Duke University where strict confidentiality will be maintained. No workers will be identified by name.

Work-related injuries can interfere with work and leisure activities. Even if you have never experienced a work injury, you very likely know someone else who has been injured at work. Although participation in this project is entirely voluntary, we hope anyone experiencing an injury will help with this effort. Sharing your experiences with fellow carpenters may provide information that can be used to help make construction sites a safer place to work.

If you have any questions about this project, you may call Dr. Hester Lipscomb at (919) 286-3232 Ext. 256, or Sue Naert at the Carpenters' District Council - St. Louis at (314) 644-4800, Ext. 221. Any of these calls may be made collect.

(L-R) Jim Nolan, Local 2119; Denny Patterson, Local 1310; Hester Lipscomb, Duke University; and Jon Dement, Duke University.

* SLIPP is a three-year project to identify measures to prevent injuries to carpenters who do residential or drywall work in St. Louis. The project is being undertaken by the Carpenters' District Council, the Home Builders Association (HBA), affiliated drywall contractors, the Health and Safety Fund of the United Brotherhood of Carpenters and Joiners, and researchers from Duke University Medical Center at N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH).

Duke

by Hester Lipscomb, Ph.D., Assistant Research Professor

ST. LOUIS INJURY PREVENTION PROJECT (SLIPP)

In late August, a group of contractors officially began reporting injuries that occurred among carpenters on residential or drywall work sites for the St. Louis Injury Prevention Project (SLIPP). As soon as these injuries were reported to the project office, Jim Nolan and Denny Patterson, two journeyman carpenters, began contacting carpenters who had been injured.

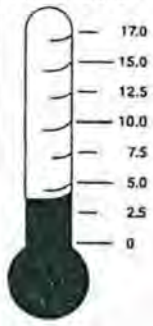
Nolan and Patterson are gathering information about what happened, and they are asking carpenters about how their injuries might have been prevented. Jim and Denny also began going out to the job sites where falls had occurred.

In the first month of the project, 65 injuries were reported. Although we have had some difficulty locating everyone, overall the vast majority of carpenters who have been approached have been willing to talk openly about their injuries. Many expressed support for the project and they are glad that the union is participating in this effort.

Thanks to all of you who participated in the early stages of the project. In addition to those who have provided information about their injuries, we also want to thank the carpenters who helped us in the development and testing of our questionnaires earlier in the summer.

We will continue recruiting contractors to participate in this project since this is the way we are able to learn about the injuries that occur. We certainly hope that none of you will experience an injury on the job, but we appreciate the time and interest of those who have had injuries. By getting information about a large number of injuries over the next few years, we hope to learn how they can be prevented. All information provided to any member of the project staff is confidential, and as we let people know what we are learning, no carpenters or contractors will ever be identified by name. Thanks for your support!

MAN HOURS



Goal of 17,000,000 for the 1999-2000 Plan Year!

May-July '99
4,394,567 Hrs.

144,569 Ahead

DUKE

by Hester Lipscomb, Ph.D., Assistant Research Professor

SAINT LOUIS INJURY PREVENTION PROJECT (SLIPP) UPDATE

SLIPP is a study being done through collaborations of epidemiologists at Duke University Medical Center, the Carpenters' District Council, the Home Builders' Association of Greater St. Louis, and a group of affiliated drywall and residential contractors in the St. Louis area.

Since we started the project a number of people have asked me "What is an 'epidemiologist'?" Epidemiologists study the distribution and determinants of disease or other health-related conditions in defined populations. The goal of this information is the prevention or control of these health problems. The word comes from 'epidemic' as the first epidemiologic studies focused on the outbreaks of infectious diseases.

In this case, SLIPP is a study of injuries among union carpenters who work on residential or drywall sites in the St. Louis area. By collecting information on a large number of injuries, we hope to gain a better understanding of causes of injuries, what groups are most at risk for certain types of injuries, and how we might prevent these events from occurring. The strength of this type of work comes not from what any one person can tell you about an injury, but from identifying the patterns of injury among a larger group.

Twenty-four contractors are now participating in the project by reporting injuries to the project office at the CDC. Denny Patterson and Jim Nolan, two journeymen carpenters, then interview injured workers — providing an opportunity for carpenters to talk to other carpenters about their injuries and how they occurred. Since we began collecting information in mid-August, approximately 200 injuries have been reported. Denny and Jim have been able to talk directly with about 70 percent of these injured carpenters. As we begin to look at this data, we want to share with you what we are finding.

To date, the vast majority of injuries have occurred while building single family homes. More than half of the injuries occurred in framing the first (26.9 percent) or second story (17.3 percent) of a home or in roofing (12.5 percent). Half of the injuries occurred when the carpenter had been working on that particular job site for five days or less. Twelve percent of the injuries were the result of an action of another worker nearby. In only 10 percent of the injuries was the carpenter doing a task with which he was unfamiliar when he got hurt.

In the charts below you can see the parts of the body which were injured and how these injuries most commonly occurred. Injuries were most common to the hand and fingers — and these were most often caused by nail guns. Back injuries and injuries to the knee were the next most common. The largest number of injuries occurred from being struck by something, followed by overexertion when lifting, carrying or pushing or pulling materials. As we gather more information, we will give you more details about the circumstances surrounding injuries .

Many thanks to the carpenters and contractors who have helped with the project to date. **We remind everyone that all the information you share is confidential and no information will be revealed about any individual carpenter.** We hope that the information you share will be used to help make the workplace safer for all.

Body Parts Injured

Mechanism of Injury

Duke

by Hester Lipscomb, Ph.D. Assistant Professor, Duke University Medical School; Jim Nolan, Local 2119; and Denny Patterson, Local 1310

SLIPP* UPDATE

It has been a while since we gave you an update on the St. Louis Injury Prevention Project (SLIPP). We continue interviewing carpenters who have had injuries at work and visiting work sites where falls have occurred. As we talk to more injured workers and go out to more sites, we are learning more about the circumstances surrounding these events. We are about at the halfway point of this project, and we felt this was a good time to provide you with a report of our progress. In fact, we now have enough data collected that we plan to give you more regular information about what we are learning.

Since the project officially got underway in the fall of 1999 through the end of December 2000, 419 injuries have been reported and 306 injuries have been investigated through interviews and/or job site visits. These injuries come from 20 contractors who are working with us on the project. When we are able to reach injured carpenters by phone, (80 percent) they have talked with us about their injuries. These men (no injuries reported in women yet, but we assume they would help as well!) are helping us learn more about safety issues in carpentry. Many times you can learn things from looking at a group of events that you may not have realized in looking at only a few.

Over half of the injuries we have seen involved the carpenter being struck by something. The circumstances surrounding these injuries and the injuries sustained are quite variable. Nail gun injuries were the single most common cause of these injuries. However, there have also been 13 injuries in which the carpenter was struck by very heavy objects such as steel I-beams, TGIs, plywood sheets, a ladder, part of a scaffolding, and framed walls that fell over.

The second most common group of injuries (25 percent) were caused by lifting, carrying, pushing or pulling, or reaching. The injuries from these activities were most common to the back, but also involved the knees, shoulders, and hernias. Over a third of these injuries involved moving bulky materials that weigh over, sometimes well over, 100 pounds — raising framed walls, placing steel I-beams, handling joists or trusses.

The third most common group of injuries were falls. As you might imagine, falls are responsible for more of the very serious injuries we have seen. Fifty-six falls have been investigated including 37 from high heights, and 19 that involved a worker who fell, but not from a high height. The falls from the same level, such as slips and trips, largely involved housekeeping problems, problems with access to or egress from the structure, the terrain or grade of the lot, or weather conditions. Workers who fell from the same level usually sustained bruises or sprains, although four had fractures demonstrating that these slips and trips do not always result in minor injuries.

We looked at falls from elevations in two categories; those that occurred when work was being done at less than six feet high and those that occurred when work was being done at six feet or above. When work is done at six feet or higher the carpenter should be covered by the OSHA fall protection standard. Falls from less than six feet most commonly resulted in sprains, strains or bruises, but also resulted in a rib fracture, a shoulder dislocation, and one death. This devastating fall occurred from a step ladder, but the work surface below was concrete. Over a third of falls from over six feet resulted in fractures that involved the skull, pelvis, spine, ribs, forearm, foot, and multiple sites. These findings clearly demonstrate the seriousness of falls from over six feet, but also how serious falls from lower elevations can be.

Learning directly from a group of injured carpenters about their injuries drives home how dangerous the work of a carpenter can be every single day. We have a long way to go, but already some good things have come of this work. We had described how common nail gun injuries appeared to be, particularly among inexperienced workers.

In January, the Joint Apprenticeship Training School started a training program on nail guns for apprentices. This program combines classroom training with hands-on experience with a wide variety of guns. Programs of this nature are not the sole solution to this problem — supervised use for inexperienced workers, continued attention to safety measures by all users, and even engineering solutions may help reduce injuries. This is a great example of how collaborative work, such as this, can create change.

In closing, we know that without the cooperation of the contractors who are working with us and the participation of the carpenters who have taken the time to talk with us about their injuries, some of them at length, we would not be able to do this work. We thank all of you for your trust and your commitment to this process. We remind you that the information we collect is confidential. We do not report any of our findings with any carpenter's or contractor's names attached. The information you provide is sent to Duke University where strict confidentiality is maintained. We only want the opportunity to learn about these injuries from you in hopes that together we can make construction a safer industry in which to work. We welcome your comments, suggestions, or questions at any time. Feel free to call any of us: Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481.

* **SLIPP** *is a three-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH).*

Duke

*St. Louis Injury Prevention Project (SLIPP *)*
Hester Lipscomb, Ph.D., Assistant Professor Duke University Medical Center;
Jim Nolan, Local 2119; and
Denny Patterson, Local 1310

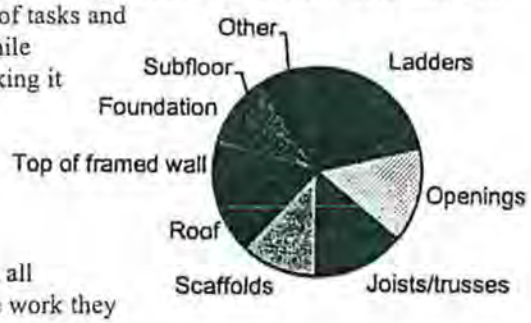
DO YOU KNOW HOW DANGEROUS YOUR WORK IS?

This month we begin a series of articles on falls. As we reported to you last month, **falls are the third most common group of injuries that have been investigated through SLIPP, and they have been responsible for more of the serious injuries we have seen.** As of March 1st, 44 falls from elevations have been investigated by talking to the victim and/or visiting the job site where the fall occurred.

These falls have not just been injuries of inexperience. The carpenters who fell had been in the union from less than a year to 25 years; half had been in the union four years or more. Based on the number of falls in these data, we estimate that among 200 apprentice carpenters working 2,000 hours in a year, five would experience a fall from a height. Similarly, among 200 journeymen we estimate that three would fall each year.

The distance fallen ranged from a foot to 24 feet, and 64 percent occurred from six feet or above the height at which the worker should be covered by OSHA fall protection regulations. Eighty-percent of these falls resulted in lost time from work. Serious injuries were more likely to have occurred when the carpenter fell a greater distance. However, we have seen serious injury, and even death, from falls from under six feet. **The seriousness of the injury is determined not just by the distance fallen, but the way the person falls and lands, how much they weigh, the surface onto which they fall, what they may hit as they fall and land.**

The surfaces from which carpenters fell are presented in the figure below. As you can see, carpenters fall from a wide variety of surfaces—ladders, through openings, scaffolds, roofs, out of buildings, down steps, and off the walls of buildings that are being constructed. These falls reflect their wide variety of tasks and exposures while working, making it a very big challenge to train and protect carpenters adequately in all aspects of the work they do.



A number of things contributed to these falls—guardrails were missing, improper equipment, poor work practices were used, and some carpenters had likely not had adequate safety training. Carpenters also reported weather, slippery work surfaces, time pressures, site housekeeping, the behavior of a co-worker, and inadequate help or communication as contributing to the falls.

Only one carpenter reported using any fall protection equipment at the time of his fall. Some carpenters who fell told us they were not doing things the way they usually did on the day they fell. They reported thinking "it just was going to take a minute," or "I usually do tie off," "I was in a hurry," or "it was raining and I just thought it would take a second." All of us have done things that were not safe and think we will get by with it, and many times we do. Unfortunately, that may make us more likely to assume "it won't happen to me."

The findings through SLIPP are not unusual. We know that falls are the fourth leading cause of all occupational fatalities in the U.S. with an average of more than 500 workers a year losing their lives in work-related falls. **The highest rate of deaths from falls occur in the construction industry, where falls are the leading cause of work-related deaths.** Although there is some variation from place to place and year to year, more than 25 percent of deaths among construction workers are the result of falls from a height. In addition to these obviously devastating events, **each year approximately 100,000 construction workers are injured by falling.**

Remember when you go to work each day, that carpenters are among the most likely workers to be injured and to die from work-related falls. The best way to protect yourself is through knowledge of hazards and fall protection systems. If you have not had fall protection training ask your contractor. They are required to provide fall protection training under OSHA.

If you do not know about job site fall protection plans, again, ask your contractor. A fall protection plan that workers are not aware of is not useful. Watch out for each other. Take responsibility for co-workers as well as yourself. If a co-worker is not being safe on the job, take responsibility for him/her as well. Do not let co-workers use poor work practices on your sites. Never assume another worker left the work area safe; watch for fall hazards as you work. **Never assume you will not fall.**

*** SLIPP** is a three-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis (CDC-St. Louis), the Home Builders Association of Greater St. Louis (HBA), affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO), and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us—Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314)867-1563; Denny Patterson (618)939-3481.

SLIPP St. Louis Injury Prevention Project

Hester Lipscomb, Duke University Medical Center
Jim Nolan, Local 2119
Denny Patterson, Local 1310

Ladders are a common and essential tool of carpentry work. Work on ladders is likely second nature to carpenters — from early apprentices to very experienced journeymen. Yet these devices present significant fall hazards to construction workers. Although many workers in multiple trades work on ladders, **construction workers are responsible for nearly half of all falls from ladders that result in fatalities** in the U.S. each year. Since we began SLIPP in the fall of 1999 through the end of March, 2001, we have investigated 45 falls from heights. Nine of those falls (20 percent) were from ladders. The injuries sustained have ranged from fairly minor contusions (or bruises) and sprains to spinal fracture and death. Brief descriptions of these falls follow.

Ladder failure: Carpenter was working from an aluminum ladder putting soffits on a porch. The ladder leg buckled and he fell.

Use of upper section of extension ladder: Carpenter had the top of an extension ladder on a front porch slab. He was up about 16 feet and the ladder slid into a 16 inch drop off causing him to fall. He had been in a hurry to finish up a few things on site.

Ladder not set on stable ground: Carpenter was using an extension ladder, handling a 15-foot manufactured truss. The ladder sunk on one side with worker and he fell off.

Fall from step ladder to concrete: Carpenter was working on a stepladder using a battery operated drill. He was found on concrete pad after having fallen and hit his head. The ladder was down and it appeared he had slipped as he descended the ladder.

Ladder set too steeply: Carpenter was on 40-foot extension ladder with one hand on ladder jack and one on Pic board. The ladder was set too steeply. He lost his balance and fell backwards off ladder.

Ladder slipped: While working on stepladder set in mud, the ladder legs slipped and this man fell off the ladder. His shoes were also muddy.

Slips: This carpenter slipped off as he was descending a job-made ladder; may have caught pant leg on nail.

Step ladder not open: Carpenter had climbed an unfolded stepladder leaning against wall. The floor was wet and the ladder slipped, causing the man to fall.

Contact with electrified pipe: This carpenter was on a stepladder and came in contact with a pipe that was electrified from a live wire left on by an electrician. The carpenter fell off the ladder.

Below are some common sense precautions to take when using ladders. As you can see, through SLIPP investigations we have seen falls from ladders because of failure to follow most of these warnings.

BEFORE USING A LADDER INSPECT IT FOR:

*Structural damage
*Missing or damaged safety devices — rung locks, lock spreaders, safety shoes/spikes
*Grease, dirt, etc. that might create a slip hazard
*Paint or stickers that could hide possible defects — except warning labels
**Damaged ladders should be removed from use, tagged or marked clearly for repair or replacement.* DO NOT USE A DAMAGED LADDER!

ANY TIME YOU ARE USING A LADDER:

*Wear slip-resistant shoes. Be sure they are not muddy.
*Keep the area around the ladder clear both at the top and the bottom.
*Use a hoist or pulley for heavy or awkward materials — do not carry heavy materials up or down a ladder yourself.
*Keep both hands free for climbing.
*Face the ladder and maintain 3-point contact (2 hands and one foot or 2 feet and one hand).
*Use ladders only for their intended purpose
*Don't load the ladder beyond its maximum intended load — know the manufacturers recommendations.

The table (below) summarizes maximum working loads for different types of ladders — the load includes the weight of the user, materials, and tools.

TYPE	DUTY	DUTY RATING
Type IA	Extra heavy	300 pounds
Type I	Heavy	250 pounds
Type II	Medium	225 pounds
Type III	Light	200 pounds

Portable ladders are most common in residential construction. A portable ladder needs to be tall enough to reach the work safely, have a load rating that can support the worker and materials, and have nonconductive sides when working near energized equipment.

WHEN USING STEP LADDERS:

*Use only on stable, solid surfaces.
*Never use folded up.
*Fully extend and lock spreaders.
*Never climb or stand on leg braces, top step or tray.
*Avoid using in unprotected doorway or high traffic areas.
*If you must use in a traffic area, mark off, have a co-worker monitor, or barricade the area until you are finished.
*Carry tools in a tool belt or in your clothing — not in your hands.
*Maintain three-point contact when ascending or descending the ladder.

WHEN USING NON-SUPPORTING LADDERS (EXTENSION LADDERS OR STRAIGHT LADDERS):

*Use ladders only on stable and level surfaces unless secured to prevent the ladder from slipping or falling.
*Extend ladder rails at least three feet above the upper landing
Use 4:1 ratio to set the ladder** — place the ladder out 1 foot for every 4 feet of height (4 feet away from the vertical support for a 16 foot ladder). ***A general rule of thumb is to place your feet at the base of the ladder; extend your arms, and your hands should just touch the side rails.
*Have another person hold the ladder during ascent and descent or tie, stake, or foot the ladder in place (top and bottom).
*Set the ladder so both rails maintain contact with the supporting structure.
*Use adjustable feet to level the ladder if needed.
*Never lean more than 12 inches beyond either rail. ***Belt-buckle rule: always keep your belt buckle inside the side rails of the ladder.***
*The third highest rung is maximum climbing height.

Prevention materials adapted from "WORKER DEATHS BY FALLS, A Summary of Surveillance Findings and Investigative Case Reports," NIOSH, November, 2000.

* **SLIPP** is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis and Vicinity, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers= Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. *Feel free to call any of us. (Hester Lipscomb at (919) 286-1722 , Ext. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481).*

ALL UNION MEMBERS

In June, your Local will hold an election for your Local's officers.

St. Louis Injury Prevention Project (SLIPP *)

Hester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center; Jim Nolan, Local 2119; and Denny Patterson, Local 1310

LITTLE THINGS CAN MAKE A DIFFERENCE

Through the SLIPP project we are learning a lot about how carpenters get injured on residential construction sites — both by talking to workers and by visiting sites. In this issue, we present what would seem to be pretty simple, minor issues that end up causing annoying and sometimes very significant injuries. The prevention of these injuries does not require a lot of time or effort.

Housekeeping issues have contributed to many different types of injuries we have seen. Materials scattered on sites can cause slips and falls as well as injuries from working in awkward postures as folks try to maneuver around when there is no clear path. The terrain on sites is often not leveled out and dips in the surface can be obscured by trash creating a trap — this can be particularly true if you are carrying something. Poor housekeeping has even contributed to some of the nail gun injuries we wrote about earlier by causing a person who was holding a nail gun to trip and discharge the gun unintentionally.

Although we try to get to the site as soon after a fall as we can, because of reporting there is sometimes a delay of several days or even a week before we get there. It is not uncommon to find the same conditions described by an injured worker when we go on a site — for example, a hole that someone fell into that is still not filled or remains covered by trash.

Since we started collecting information, we have seen more than a dozen workers who were cut by metal bands that secure materials when they are delivered to construction sites. Although some of these were not bad cuts, they did require visits to an emergency department or physician's office for stitches. Some were more serious and required more extensive repair and time off work.

The circumstances surrounding these injuries varied. Several occurred when someone used the claw end of their hammer to pull a band off causing the band to fly back and hit them. Others occurred when loose bands were left around materials as they were being used, creating a hazard for people who walk by. Others occurred when the bands had gotten lodged in the mud and came loose causing a dirty cut.

It is not practical to be able to put these bands in a trash area as soon as they are broken because materials are still often stacked on them. However, as soon as you can discard these bands, get them in a trash area or dumpster so no one will get hurt by them. When you remove the bands, use a pair of snips to cut the band and wear gloves. The bands are often under tension and will fly back at you. Fold the ends back near the ground so there is not a sharp edge on the end until they can be removed to a trash area.

This is a task that is not likely to be assigned to anyone — but doing it may keep you or a co-worker from getting cut. After the bands are broken or removed, watch out for materials that are in the stack. As materials are removed, others often get dislodged and can fall on you causing injury besides causing tripping hazards.

With warmer weather, it is very important to be sure you get enough fluids while you are working. However, remember that bees are attracted to sweet drinks. They can get into a soda can, Gatoraid, or juice can without your knowing it. We have talked to several men who got stung after they drank something a bee had gone into.

This type of injury is largely a nuisance, but it causes discomfort to the injured worker and can be serious. Using a cup with a lid and straw does not prevent this from happening as a bee can go down a straw as well. Remember that bees will not be as attracted to non-sweet drinks, and keep whatever you are drinking covered up. Be careful and save yourself some grief.

Do not accept bad housekeeping on work sites. There should be a designated area for trash and a regular policy about clean-up. However, mess occurs all the time as houses are being built just by the nature of the work. If clean up is not scheduled but you have created a hazard for yourself or someone else, take care of it. If someone has already been hurt on your site, take a few minutes to see what caused the injury and correct the problem when you can. The injury you prevent could be your own. By accepting a messy work area, as many are, we are accepting the risk that goes along with the mess.

So many injuries in carpentry are caused by complex issues and dangerous work issues that are much harder to address. These are examples of some injuries that can be prevented by pretty straightforward actions.

* SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis and Vicinity, The Home Builders Association of Greater St. Louis (HBA), affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at any time. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481).

St. Louis Injury Prevention Project (SLIPP *)

Hester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center; Jim Nolan, Local 2119; and Denny Patterson, Local 1310

EYE INJURIES

Eye injuries are common work-related injuries in construction. The Bureau of Labor Statistics estimates that 12 percent of all work-related eye injuries that are severe enough to require time away from work occur in the construction trades which employ less than six percent of private sector workers. Of the injuries reported through SLIPP, eye injuries are the third most common, following only injuries to the hand and the back. This is a similar pattern to one we observed in a study of eye injuries among carpenters in Washington State.

In that study, we were analyzing coded workers' compensation claims data, and we were unable to determine what the carpenter was doing when injured — whether safety glasses or goggles were used and failed, or whether the injury had been caused by the work of someone else nearby. Through SLIPP, we have the advantage of being able to talk with the person who was hurt shortly after the injury, and we have been able to explore some of these issues.

In the St. Louis area, we have investigated 37 eye injuries since we began the project. The vast majority (over 90 percent) of injuries involved foreign bodies in the eye, such as sawdust and metal particles or chips. There were also two cuts and one puncture wound. Two types of activities were most commonly associated with these injuries — operating power tools, specifically saws and nail guns, and doing overhead work.

The injuries from saws largely involved sawdust. The nail gun injuries involved toenailing activities in which a nail fragment flew back into the person's eye. The overhead work involved tasks on ceilings and gutters, as well as passing materials up to someone when debris fell down into the person's eyes. One fairly serious injury was caused by a piece of nail that flew back into the carpenter's eye when he was hammering and another eye injury was caused when cutting off a nail with pliers.

In 18 cases (49 percent of the cases studied), the carpenter was wearing safety glasses when he got a foreign body in his eye. There were several reports of particles blowing around the sides or over the top of the glasses sometimes when doing overhead work. However, in several cases, the carpenter was unsure how the particle or dust got in his eye. **No one reported the use of goggles.**

In only one case was the eye injury a bystander injury, when a worker got sawdust in his eye from a co-worker's power saw. In a number of cases, the carpenter mentioned the wind blowing and debris from the saw as contributing factors. There were a few cases when the person thought debris had come off their face, hard hat, or from their safety glasses as they were removed.

While the number of injuries sustained despite the use of eye protection is discouraging, it is important to remember that through SLIPP we only talk with people who report an injury. We do not know how many injuries have been prevented by use of eye protection — even if it is less than perfect!

From these data, there a number of recommendations that are pretty clear cut.

(1) Always wear eye protection when operating power tools and doing work overhead.

(2) Use of safety goggles may be more effective when doing tasks where there is a greater likelihood of particles getting around the edges of the safety glasses.

(3) Be aware, when using a hammer, that the nail chips can cause serious eye injuries.

(4) Be careful as you remove dusty or dirty eye protection. Debris can be on your face, your eyebrows, or hard hat.

(5) As you pass materials up to others, be sure there is no debris that may fall on your face and in your eyes — even if you are wearing safety glasses.

***SLIPP** is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 487-1563; and Denny Patterson (618) 939-3481).*

Attention All Members

As of August 1st, the main number for the administrative offices at the Construction Training School will be (314) 647-2941

St. Louis Injury Prevention Project (SLIPP *)

by Hester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center
Jim Nolan, Local 2119, Denny Patterson, Local 1310

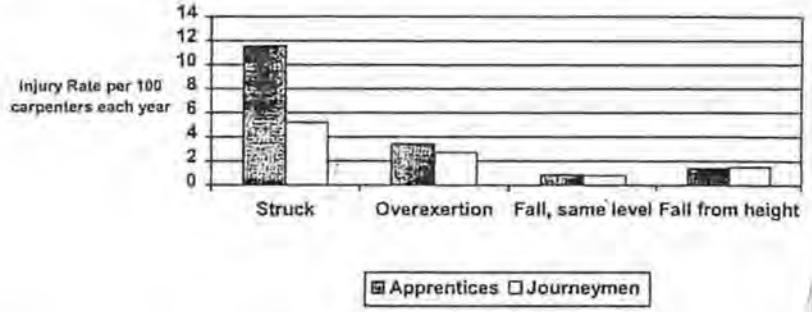
TWO YEARS LATER

September of this year marked the two year anniversary of data collection through SLIPP. Since we began the effort, 592 injuries have been reported. We have presented preliminary results at a number of different places. We have done workshops for carpenters at Workers' Memorial Day for the last two years at St. Louis University, and we have recently been invited to participate in this meeting again in May 2002. We have also presented some of our findings at the National Institute for Occupational Health and Safety (NIOSH), National Occupational Injury Research Symposium, the National Safety Council Congress and Exposition, and the International Symposium on Epidemiology in Occupational Health.

At each of these meetings, there has been a lot of interest in the project for a number of reasons. The collaboration we have had for this project from the union and participating contractors is a pretty unique situation. Construction workers are difficult to study because they work on different sites, often with only a few carpenters per site, and the conditions constantly change as the work progresses.

Others are surprised by the participation rates of 75-80 percent which we continue to have from injured carpenters. These men (still no injuries reported among women carpenters) agree to be interviewed, allowing us to learn a tremendous amount about their injuries and the circumstances surrounding these events. By sharing their time and information, they allow others to learn from their experiences.

Over two years, we have injuries reported from carpenters who worked nearly seven million MAN HOURS in residential or drywall work. From the injuries reported, we estimate injury rates to be just under 18 for every 200,000 MAN HOURS worked — meaning 18 out of every 100 full-time carpenters are hurt each year. As we have reported before, apprentices have higher rates of injuries than journeymen; one in five apprentices are hurt each year compared to one in 11 journeymen. The patterns of injury are different for apprentices and journeymen as you can see in the chart to the right for the four main types of injuries we nave seen.



Apprentices have rates of injury twice as high as journeymen from being 'struck by,' (or against), something. These injuries often involve power tools; 30 percent of these injuries in apprentices are from nail guns compared to 10 percent among journeymen. The injuries we have described as 'overexertion' are largely the result of manual materials handling tasks, lifting, pushing or pulling, or carrying. Journeymen have more of these injuries that involve the shoulder, whereas apprentices have more that involve the back. Although falls occur at much lower rates than other injuries, they are the most serious, and costly, injuries. These potentially devastating injuries occur at very similar rates for journeymen and apprentices.

Besides learning about individual cases, at this point, we are able to describe patterns of injury among different groups. This can help us understand more about why injuries occur, but can also help focus where preventive efforts might be most useful. The differences between apprentices and journeymen are likely a reflection of a number of things — experience and training, but also the type of work apprentices do compared to journeymen. For example, we know apprentices do more packing of lumber and materials which may make them more likely to experience back injuries. We also know that falls are not injuries of inexperience, a clear indication that efforts to prevent falls need to involve all workers, regardless of their level of experience or training.

As we continue this effort, we are interested in your ideas or suggestions. The numbers to call us are listed below. We thank those of you who have helped directly in the last two years. We will continue to share our findings with you as the process continues.

* **SLIPP** is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis and Vicinity, the Home Builders Association of Greater St. Louis (HBA), affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481).

St. Louis Injury Prevention Project (SLIPP *)

Denny Patterson, Local 1310; Jim Nolan, Local 2119; and Hester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center

THE WEATHER IS CHANGING. YOU SHOULD AS WELL.

Carpenters face the elements as they build. This creates a whole set of challenges that are foreign to individuals who work inside buildings, where weather only affects them as they go to and from work. With winter upon us, we thought we should share information we have about injuries related to winter weather conditions. In the last two years, we have talked with 30 carpenters who had injuries related directly to weather conditions — as well as several others where weather contributed in some way to there injuries. These injuries illustrate some of the dangers associated with rain, cold; snow, and wind.

Injuries related to weather ranged from sprains and strains to fractures and head injuries. We have seen a number of knee and ankle injuries from slipping in mud. We also have seen several injuries that occurred while trying to move materials in adverse weather. As you know, heavy trusses and awkward materials become even more difficult to deal with when you must also contend with mud or snow.

We have seen falls from heights that resulted in more serious injuries. One carpenter slipped from mud on his boots and fell through an opening. Another fell off a roof when he went to retrieve his tools in the rain. There were a number of injuries involving ladders. We saw ladders that slipped on wet surfaces, a ladder that sank into damp ground, both causing the men on them to fall. Another ladder got caught by the wind and fell over hitting a carpenter standing near by. Several months ago, we presented information on increased risk of eye injuries from blowing debris under windy conditions.

Certainly, the opening should have been covered, ladders should have been staked or set securely, and the carpenter on the roof should have had better fall protection. However, all of these folks were at more risk because of the weather conditions. Ice and snow are not the only winter weather hazards. Wet conditions create serious fall hazards by causing slippery surfaces.

Mud caked on boots also adds weight, making it more difficult to work, as well as creating dangers of slipping. Wind can catch materials with which you are working making it more difficult to carry objects and maintain your balance. Wind can also catch ladders, tipping them over or making them difficult to carry.

* Work cannot go as rapidly, and still be safe, under adverse weather conditions. It may take more people to safely move materials under adverse weather conditions.
* Fall protection measures become even more important in adverse weather, when slip and trip hazards are compounded.
* Housekeeping becomes more important in the winter. Even a light dusting of snow can hide all kinds of traps. Try to plan areas that can safely be used as paths to and from materials; use gravel when you can.
* Be aware of your footing, especially in the morning when there is frost in shady areas. This applies not just on site, but when you are headed to your truck in the morning as well.
* When the weather turns cold, it is more important to warm up in the morning and after lunch. At least do some stretching to limber up.
* Tools are susceptible to cold weather. Moisture in a tool can turn to ice particles and cause misfires in a nail gun or make a saw feel different.
* Materials become more brittle in cold weather, especially if there is moisture. Be aware that things will handle differently in cold conditions.
* Clean your boots regularly, especially before you work at any height. Added weight of mud makes them more dangerous, besides creating a slip hazard.

* **SLIPP** is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us, [Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; Denny Patterson (618) 939-3481].

St. Louis Injury Prevention Project (SLIPP *)

Hester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center;
Jim Nolan, Local 2119; Denny Patterson, Local 1310

DRYWALL INJURIES

Most of the reports we have shared with you about the SLIPP project have focused on residential carpentry, particularly framing. This month, we wanted to share information about injuries of carpenters performing drywall installation. We have talked with 68 carpenters who were injured while working on drywall projects. As you can see from the pie chart (below), these injuries most commonly involved the hand and fingers; followed by the arm; then the knee, back, and eye in almost equal numbers. As in other carpentry work, carpenters installing drywall were most likely to be struck by or against something; to be hurt lifting, pushing, or pulling handling materials (we called these overexertion); or from falls. However, the circumstances surrounding these injuries are different than those we see most often in residential framing. The injuries caused by being struck usually resulted in cuts and contusions. The most common thing that drywall carpenters were struck by were knives and metal framing studs, but it is also possible to be struck by a buck hoist, parts of scaffolding, or drywall horses.

The falls from elevations were from a short list of work platforms — namely Bakers or Perry scaffolding, pic boards and ladders, and drywall horses. The scaffolding falls were caused by a variety of circumstances, but were most often related to work practices — scaffolds that were improperly erected, trying to move the scaffold by pushing against the wall, or rolling a scaffold into a hole for a vent.

The injuries from handling materials, or installing drywall, involved the arms and shoulder, back, and knees. Some of these injuries involved working in very tight situations where awkward postures were used. Many involved carrying or passing sheets of drywall repetitively over the course of a work day. Some involved slips and trips while carrying materials that resulted in twisted knees and wrenched backs.

The eye injuries often involved metal shavings that got in the eye from overhead work, and sometimes with shavings falling in over the top of safety glasses. There were also a couple of injuries involving electric shock from contact with wiring, stepping on objects, and wires being abraded.

Drywall installation is clearly an area that could benefit from some engineering solutions. The work is typically fast-paced, heavy, repetitive, and puts people in awkward postures. Newer housing designs and commercial projects require work at significant elevations, as well. Use of metal studs create safety challenges handling sharp edges. From the injuries we have described, there are some things to think about when doing this work that could prevent injury to you and your co-workers.

* Any work at heights is dangerous — don't assume that work on a Baker's scaffold is safe. Know how to safely erect the scaffolding and use good work practices when you are on them. (More on this another month!)
* Use gloves when you can to protect yourself from cuts, especially when handling metal studs.
* Watch out for possible danger created by others — do not assume the current is off when working around wiring.
* Drywall installation creates debris and that creates slip and trip hazards. These become especially important when you are moving heavy and bulky materials, like drywall, that blocks your view.
* Drywall sheets are getting larger and heavier, and consequently more difficult to move. Ask for help moving materials and realize that the work may not be able to be done as rapidly, and still be done in a safe manner, when using big sheets.
* Do not burn out apprentices who are often expected to haul the bulk of the drywall on a job. They are not invincible either.

** **SLIPP** is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, EXT. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481).*

St. Louis Injury Prevention Project (SLIPP *)

Jim Nolan, Local 2119; Denny Patterson, Local 1310;
Rester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center

WORK ON FREE STANDING SCAFFOLDS

As we mentioned last month, the falls from elevations among carpenters hanging drywall have been from a short list of work platforms — most commonly free standing scaffolds such as Baker's or Perry scaffolding. The scaffolding falls were caused by a variety of circumstances, but were most often related to work practices — scaffolds that were improperly erected, trying to move the scaffold while still on the platform, or rolling a scaffold into a hole for a vent.

Any work at height is dangerous and falls remain the leading cause of serious and fatal injuries in construction. For carpenters who work on scaffolding, knowing how to safely erect scaffolding and using good work practices on them is important. Do not assume that work on a free standing scaffold is safe — even if you have done it for some time without mishap. These scaffolds are typically narrow and can tip easily — especially as you load them with heavy sheets of drywall. Scaffolding can also cause other serious injuries besides falls; collapse can be deadly for those on the scaffold and those nearby, moving these awkward and heavy platforms can be difficult, and they can create electrical hazards.

Stability is essential to the safety of a scaffold. OSHA provides a "1-to-4" rule for requirements of outriggers — for every foot of width, the scaffold platform can go up four feet high without use of outriggers. In other words, a typical 30 inch wide scaffold would need outriggers for stability at 10 feet (30" x 4=120" or 10 feet), as well as fall protection handrails and toe boards. California and Ohio allow only a "1-to-3" ratio, in which case a two foot wide scaffold could only go up six feet without outriggers. Remember OSHA regulations are a minimal requirement — you do not have to wait until you exceed the "1-to-4" rule to use outriggers.

* Watch out for possible danger created by others — always check a scaffold before you get on it. Inspect erected scaffolding frequently. Be sure side brace lock pins are fully engaged before getting on the platform, and be sure the platform is properly seated within the side brace channel and clipped. Be sure wheels are locked in position.
* Climb over the top of the end frame; do not swing around the side of the frame as you mount the scaffold.
* Remember, the "1-to-4" (or better!) rule and use outriggers as needed to allow for a stable work platform. If the work area does not allow this, then the scaffold must be tied to a solid structure. Never use more than one frame high without outriggers.
* There should be at least two side braces installed on each scaffold level that are evenly spaced.
* Use toe boards and guard rails to protect yourself and others.
* Never ride a rolling scaffold; do not try to move the scaffolding while you are on it. Get sufficient help to move the scaffolding; watch for holes or obstacles on the floor. When moving a scaffold, push or pull at the bottom end frames as close to the scaffold as possible. Do not attempt to move the scaffold from the top.
* Before working on or moving scaffolding, identify any electrical hazards and take appropriate precautions.
* Apprentices you work with may not have training in scaffold erection; work with them to assure they know how to put the equipment together safely — for your safety and for theirs.

All the things we mention take time — we know that. However, they take less time as they become part of the normal routine and all of the crew understand the principles of safe set up and disassembly, as well as safe work practices on these elevated surfaces.

From our articles, you may think we are not paying attention to good work practices, but that is not true. We do see examples of work being done safely! In the early days of the SLIPP project, we were impressed with the scaffolding used by ISC Contracting, so we returned to them to get some photographs for illustration. We thank ISC Contracting for allowing us to use this photo to demonstrate some points about safe scaffold assembly and work practices.

Joe Horman, Local 2119 from ISC Contracting, works on a free standing scaffold with toe boards, guard rails, and outriggers for stability.

* SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis and Vicinity, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Let us know if we should illustrate safe work practices from your work site. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; or Denny Patterson (618) 939-3481).

St. Louis Injury Prevention Project (SLIPP *)

Jim Nolan, Local 2119 Denny Patterson, Local 1310, and Hester Lipscomb, Ph.D., Assistant Professor, Duke University Medical Center

RAISING WALLS

There are things carpenters do every day that have the potential to be very dangerous. Sometimes these are tasks that you do so often that they have become second nature, and they are, in fact, accomplished almost all the time without mishap. However, if things do not work as planned they can be very dangerous. Framing residential walls is an example of one of those things. Multiple walls get framed, raised, and braced as every house is built; and most of the time no one gets hurt. However, this task involves a number of potentially dangerous steps or activities.

We have seen a number of injuries associated with this task. Some of these involved injuries to the back or shoulders from lifting; sometimes caused by one person dropping their load and shifting weight to others unexpectedly. We have also seen a number of injuries caused by walls falling as they were being lifted, that had been propped up, or after being braced. We have also seen injuries from inside walls that were being framed and propped up that blew over. Although we have not seen a lot of injuries from this activity, they have been some of the more serious injuries we have investigated. The margin for error with this common task is very small.

As you know, a framed wall can weigh several hundred pounds and requires several people to raise. As the wall is lifted from the floor and pushed into position, it not only requires significant effort but also coordination of the team doing the work. As housing designs have evolved, more and more often these walls are longer than they used to be and consequently heavier.

Sometimes, they are lifted after sheeting is applied making them even more of a challenge to raise. To lift the wall from the floor or ground, the carpenters involved must bend over and then, as a group, lift the wall. Bending over and lifting this tremendous weight puts tremendous force on the spine even when several people are involved. After getting it raised, the grip must be changed to allow you to push the wall up. This creates an opportunity for people to shift the load unexpectedly.

There are lift devices designed to assist with this task and hopefully they will become more accessible and useful on small job sites. Cranes are being used more to set these walls as well. When using a crane, you must be careful that the bottom does not slip out, swing, and strike someone. We have also seen injuries from walls lifted by a crane hitting, so the use of an assistive device alone does not solve the problem entirely.

* Use assistive devices whenever possible to help with the load, but they require precautions as well. 2 inch by 4 inch blocks can be placed under heavy walls with a crowbar to allow everyone a good hand hold.
* Use of sawhorses to place the wall on after it is lifted from the floor, but before it is pushed up, can allow you time to change your grip on the wall — it can give you a break.
* This is a task that requires coordination of manpower to be done safely. Remember this when you are working with a new person on your crew or if you are short handed.
* Coach apprentices as they begin helping with this task — for their safety as well as your own. What you take for granted, they may not know.
* Some walls may be too long to safely build on the ground and lift. Consideration should be given to building these in stages and connecting after they are raised.
* Once the wall is up, be sure it is adequately braced. A brace should be nailed on each of the walls at the top. As the wall is raised, it should swing down. As soon as the wall is upright, these end braces should be nailed. No one should walk away from the wall until more temporary braces are nailed. Blocks are nailed to the floor and braces are nailed to the blocks.
* Remember the power of the wind. On a windy day, walls that have been propped up can get blown over.
* Get the help that is needed; do not risk your safety or that of your crew to lift a wall that is beyond your capabilities.

* SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis and Vicinity, the Home Builders Association of Greater St. Louis (HBA), affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO), and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Let us know what you think. Feel free to call any of us — Hester Lipscomb at (919) 286-1722, Ext 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481.

St. Louis Injury Prevention Project (SLIPP *)

Hester Lipscomb, Ph.D., Associate Professor, Duke University Medical Center;
Jim Nolan, Local 2119; Denny Patterson, Local 1310

WHAT YOU ARE TELLING US.

We have reported on a variety of injuries that carpenters have sustained on residential and drywall sites and we have described circumstances surrounding these injuries. In each interview we conduct with a carpenter who has been injured, we ask a series of questions about things that might have contributed to the injury such as housekeeping on site, lighting, slippery surfaces, time pressures, weather, co-workers behavior, fatigue, use of the wrong tool, or the need for help. In addition, to these specific things we ask the carpenter to tell us what they thought contributed to their injury and how it might have been prevented. This month we wanted to share some of the things you have told us contributed to, as well as things you thought might have prevented, injuries.

Just as we have seen patterns in describing injuries, we also see patterns in these responses. Nearly a third of people who had gotten hit by something reported the injury was caused in part by the action of a co-worker. These injuries involved things like a framed wall falling over or a hand getting caught under a beam, for example.

A third of the carpenters who were handling materials felt that the materials were too heavy and they needed help. Time pressures were most often, in fact nearly half the time, reported to be associated with falls from the same level. Overall, only seven percent of the time carpenters reported that they thought poor site housekeeping contributed to their injury. However, 20 percent of those who had slips, trips, and same level falls felt poor housekeeping was a factor, as well as 11 percent of those who got hurt handling materials. It was rare for carpenters to mention having the wrong tool for the job. Although there were cases when different equipment, such as longer ladders, were needed.

Below are some examples of specific recommendations that were consistently made by injured carpenters to prevent injuries associated with different problems. These suggestions sometimes only involve the worker, but often they involve the foremen and entire crew as well as the contractor.

Heavy Tasks

* We need to recognize the need for more help for some tasks; and foremen needs to realize this too. Examples included very heavy tasks like setting beams and raising walls.
* Do not think you are a superman/superwoman; do not pack too much lumber or drywall at a time.
* Spend more time analyzing heavy tasks to be done; be sure there is enough help and that everyone knows what to do.
* Use cranes more; especially to set beams and lift heavy materials to upper floors, and be willing to wait for a crane to come if necessary.

Falls

* We need to use better fall protection even at lower heights and on low pitch roofs-guardrails, handrails, toeboards.
* Pump jacks are safer and easier to manage than ladder jacks and pic boards.
* Always check surfaces before you rely on them — scaffolds, ladders, subflooring, joists. Be sure things are built properly, well seated, and secured.

Communication

* Experience with the people you are working with is important Remember this when there is a new crewmember on your job. This includes folks from other sites who may come over to help with heavy tasks.
* We need to train apprentices better for their safety as well as that of the rest of the crew.
* Tag equipment that has malfunctioned so everybody knows, and get it off the site.

Housekeeping

* Pull nails out of boards and get rid of them; this is safer than bending them over and does not take that much time.
* Clip and bend over band irons around materials as soon as you break one. When you can get to them, throw them away.
* Fill in holes on site; better grading would help.
* Move cords out of the way.

Carpenters also report worrying about keeping their jobs and being hesitant to slow down or ask for help because of this concern. They report sometimes pushing too hard or trying to do more than one thing at a time. Overall, you are quick to accept responsibility for your own injuries—even when co-workers contributed, or you were working under less than ideal circumstances.

*SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis and Vicinity, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Let us know what you think. Feel free to call any of us — Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481.

SLIPP

Hester Lipscomb, Ph.D., Asst. Professor, Duke University Medical Center
Jim Nolan, Local 2119; and Denny Patterson, Local 1310

WORKING IN THE HEAT

Summer is upon us and we wanted to alert you to heat related problems on job sites that we saw through SLIPP last summer. In August last year, five carpenters had heat-related problems while working. All of these were resolved, although care in the emergency room with intravenous fluids was required in some cases. In one case, a carpenter lost consciousness. A worker who faints on the job because of heat may experience devastating injuries as well as their heat-related problems. Loss of consciousness while working on a roof, ladder, operating power tools, or helping others with a complex task could be devastating! In addition to these directly heat-related events, a number of summer injuries appear to have been related to heat and fatigue.

Heat can cause very severe problems as we are all aware after last summer following the publicly-reported death of a professional football player from heat stroke. Construction tasks are known to generate significant body heat even under normal conditions. There can be intense heat in the St. Louis area in the summer as well as high humidity levels. Remember that the body cools itself by evaporation. As humidity rises, sweat does not evaporate as quickly, so the body's cooling mechanism works less efficiently.

First aid can make a huge difference in the outcome for a person suffering from heat-related problems. All crew members need to be aware of basic things that can prevent problems related to heat as well as basic first aid measures for heat exhaustion. These simple measures can prevent devastating outcomes.

* Always have fluids, preferably Gatoraid-type drinks, readily available on job sites.
* Insist that everybody take regular fluid breaks.
* Do not rely on thirst to signal the need for fluids!
* Do not allow people to work to the point of fatigue in the heat.
* Work earlier hours and/or shorter hours on very hot days to avoid exposure to intense heat.

In the event of any question about heat-related problems, always be cautious.

* Never hesitate to call 911 for a worker in trouble. A quick response can make a huge difference in the outcome.
* Move the affected person to a shaded area.
* Have them lie down to maximize blood flow to the brain.
* If they are conscious, have them drink fluids.
* Application of cool water, damp towels, or ice will help lower body temperature.

(L-R) Denny Patterson, Local 1310; Hester Lipscomb, Duke University; and Jim Nolan, Local 2119: The SLIPP Project worked an informational booth at this year's Workers' Memorial Conference held at SLU on May 2nd.

St. Louis Injury Prevention Project (SLIPP *)

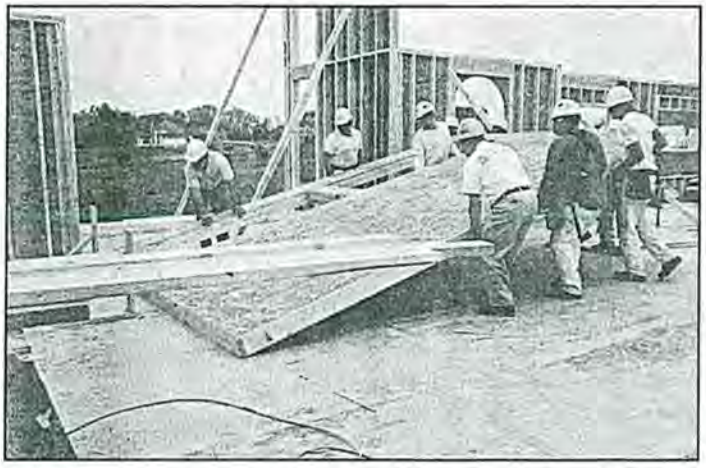
Jim Nolan, Local 2119; Denny Patterson, Local 1310;
Hester Lipscomb, Ph.D., Associate Professor, Duke University Medical Center

POWER TOOL INJURIES

This month we wanted to share information we have received from carpenters whose injuries have involved power tools. We have reported before on injuries from pneumatic nail guns; and these remain the most common power tool injuries. However, this month we are presenting information on injuries from other power tools. Since we started collecting information in September, 1999, we have talked with 51 carpenters who were injured by power tools other than pneumatic nailers or staplers.

We estimate that the rate of power tool injuries is almost 3 times higher among apprentices than journeymen. We see rates of power tool injuries among journeymen of about 2 for every 200,000 hours worked, while apprentices have an injury rate of about 5.7 for every 200,000 hours worked. These rates mean that 2 journeymen out of every 100 sustain a power tool injury each year compared to nearly 6 apprentices out of every 100 each year.

Jim Nolan checks a saw guard on a residential site.



We had a recent article on raising walls. Here a crew from Kemp Homes is raising a large framed wall. Extra crew members were brought in to handle the heavy lift. Braces can be seen on the sides that drop down as the wall is lifted to allow it to be braced quickly.

The tools that were associated with these injuries have been saws including circular, reciprocating, worm drive, and miter (75 percent); screw guns (11 percent); drills (6 percent); powder actuated tools, including Hilti and Ram set; as well as single injuries involving a grinding wheel, roto-hammer, and belt sander. 40 percent of the injuries involving power tools resulted in lost time from work beyond the day of injury.

Power saws were involved most commonly in cuts — to the hand, fingers, and forearm and eye injuries from flying debris. We have also talked with men who had cuts to the legs, finger fractures and an amputation associated with the use of saws.

These injuries involving saws have involved several common scenarios:

- Tools that bound up or kicked back. These injuries are not uncommon, particularly with reciprocating saws that do not have guards or anti-kickback devices. These injuries are hard to prevent; the tools are designed to get in tight spaces. If the blade hits something besides wood, it can kick back unexpectedly. Think about your hand placement when using these tools, but also where your legs are in relation to the saw. We have seen guys get cut when kneeling to cut openings in the floor and the saw kicked back.
- Improper hand placement. Injuries were sustained when a glove got pulled into a running saw blade, when cutting small pieces of wood when it perhaps should not have been pushed in, and touching a saw blade that was still moving after the saw was cut off.
- Eye injuries from power saws involved flying debris and are often associated with overhead work or working nearby someone operating a saw. Safety glasses, particularly without side shields do not always offer enough protection.
- Use of a saw from the roof or on a ladder in awkward positions.

The injuries from the roto-hammer and drills involved sprains. The rotohammer hit rebar and kicked back causing a sprained wrist; drill injuries were sustained working overhead causing a shoulder strain and when a drill bit got caught and twisted an elbow. The injuries from charge activated tools involved a fractured hand from being hit by a wire and a contusion from recoil.

- We all sometimes do things we know are not safe; carpenters reported "knowing better" sometimes. Always

respect your power tools, even when their use has become second nature to you. Avoid rushing when using a power tool — even if you know how to use it well.

Wear safety glasses when operating power tools. Even when someone else nearby is using a tool, debris can cause problems. This may be especially true on windy days. Be sure your glasses fit properly against Your face and have side pieces.

- Overhead work places you at particular risk for eye injuries, as well as shoulder sprains, and requires awkward postures that can put you at risk of falls. Use of goggles may protect your eyes more in overhead work. Try to get in a secure position by raising your body height to avoid unnecessary reaching.
- Apprentices report they need instruction in the proper, safe use of tools on the job site; be sure you give them appropriate guidance. They need more guidance in how to use these tools than they can get in school.
- Always be sure the blade has stopped before you put your hand nearby.
- Keep equipment clean and in good working condition. Check guards regularly to be sure they work properly; if not, get the saw serviced.
- Never use a tool that has malfunctioned until it has been serviced.

* **SLIPP** is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. **Let us know what you think.** Feel free to call any of us. (Hester Lipscomb at (919) 286-1722 Ext. 256; Jim Nolan (314) 867-1563; Denny Patterson (618) 939-3481).

St. Louis Injury Prevention Project (SLIPP *)

Jim Nolan, Local 2119; Denny Patterson, Local 1310;
Hester Lipscomb, Ph.D., Associate Professor, Duke University Medical Center

BAD FALLS – SAFETY ALERT

SLIPP investigators recently talked with two men injured in the same very serious incident. These men both fell from elevations as the surface they were working on collapsed. We felt the circumstances warranted a general warning to prevent a similar event from occurring.

These men were laying 3/4 inch plywood on 32 foot T.G.I.'s. Four stacks of banded plywood had been laid across the T.G.I.'s with 25 sheets in each stack. The carpenters were making a walkway of plywood towards the beam. They had three sheets down when the joists twisted and fell. The men road the sheet of plywood they were standing on down as it fell. Both men fell to a concrete floor below and sustained broken legs.

Ten of the joists had twisted and broken. The combined weight of the 100 sheets of plywood on the joists was around 6,000 pounds. The joists should have been staylathed in the middle of the span to have tied them together. As they were placed, once they began to twist there was nothing they could do but go down. In this situation, the manufacturers' specifications clearly warn against placing sheets of materials on these joists before they are stabilized.

We need to learn from this terrible event so no one else does this again. The 32 foot spans can be flimsy in the middle causing them to sway, but any joists should be stabilized before significant weight is put on them — including stacks of materials or people.

The injuries sustained in these falls were serious, and these men will be out of work for quite some time. They could have been worse — had the stacks of plywood come down on them that could have resulted in two deaths.

* SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Let us know what you think. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; Denny Patterson (618) 939-3481).

St. Louis Injury Prevention Project (SLIPP *)

Jim Nolan, Local 2119; Denny Patterson, Local 1310;
Hester Lipscomb, Ph.D., Associate Professor, Duke University Medical Center

A CLOSE CALL

Many times as we talk with carpenters about their work-related injuries we learn of near misses where a person could have been seriously injured or killed. We believe we can learn a tremendous amount from these situations by sharing information about what happened and how potentially devastating circumstances can be avoided. This month, we share information about an injury that occurred while setting trusses—something carpenters do every time they build a house—that could have been a travesty.

This injury occurred on a residential site where a crew of four carpenters had been working for 10 days. The weather was good and had been. The crew was setting trusses with a rig; the crane and trusses together were blocking the road. One man was on the ground hooking up the trusses. Two men were on the outside walls; another was in the center of the trusses standing on the bottom cord. They had put the girder truss up bracing it with one brace and one nail. Three more trusses were set up at one time. The middleman leaned them against the girder truss and climbed up and took the chain off. He got back down to the bottom cord and was heading over to put more nails in the brace when all four trusses fell over on him. He grabbed hold of the main trusses and did not fall to the floor eight feet below. The man was hurt, but he could have been killed—the trusses probably weighed 300 to 400 pounds and they fell four-to-five feet before hitting him. The men on the outside walls saw the trusses coming down, stepped away, and were not hurt; but they easily could have been.

In retrospect, it is easy to say that the girder truss should have been more secure before others were brought up. Afterwards, the man reported that they were hurrying because the road was blocked—an easy situation to understand—the crew was trying not to inconvenience others. However, in trying to be considerate, a devastating injury could have occurred to more than one member of this crew.

* Never hurry when setting trusses, make sure the first one you put up there is properly braced.
* Pay attention to situations, like this one, where you find yourself saying, "Boy, he or she was really lucky"... because it does not always happen like that.

* SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The National Institute funds the project for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Let us know what you think. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722 Ext 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481).

SLIPP - James Nolan, Local 2119; Dennis Patterson, Local 1310; and Hester Lipscomb, Ph.D, Associate Professor, Duke University

MORE ON INJURIES FROM NAIL GUNS: WHAT WE HAVE LEARNED

We have reported before on nail gun injuries investigated through SLIPP. This month, we wanted to give you an update. As you know, pneumatic nail guns are common tools in residential construction, allowing increased productivity, but also creating injury risks. Common triggering mechanisms on these tools include "contact trip" and "sequential triggers". The more common contact trip design allows nails to be discharged from the tool anytime the nose and the trigger mechanism are both depressed. Workers are able to hold the trigger down and do rapid-fire "bounce" nailing to speed up production. The sequential design requires that the nose be depressed before the trigger in order to discharge a nail, making it more difficult to unintentionally discharge nails.

During the 32 months of data collection, 699 injuries were reported to the SLIPP project office; 529 (75.7 percent) carpenters agreed to participate. Nail guns were involved in 69 (13 percent) of these injuries, and 63 (91 percent) of the injuries were the result of the carpenter being struck; the single greatest cause of residential carpenters being struck.

There were three falls in which the use of the tool was felt to have contributed to the fall; two from height and one same level fall. Two workers reported injuries from repetitive use of the tool, and there was one lifting injury. Injuries were more common among apprentices with 36 percent occurring in the first year of apprenticeship, 18 percent in the second year, and an additional 15 percent in the third year. The overall rate of injury from nail guns was two per 200,000 hours worked-or two carpenters out of every hundred every year. The injury rate among apprentices was 3.8 per 200,000 MAN HOURS worked compared to a rate of 1.1 among journey-level carpenters.

From our data, the type of surface nailing could be determined for all but one injury involving a tool with a sequential trigger. In one case, the carpenter was not actually nailing a surface when he was injured. In the remaining cases, the carpenter was through nailing 78.6 percent of the time, toenailing 14.3 percent, and flat nailing 7.1 percent. Circumstances surrounding injuries from tools with sequential triggers are described below. These included:

- use of non-dominant hand to reach tight spot, resulting in loss of adequate control of the tool;
- hand placement too close to nose of gun and shooting over the intended site;
- bracing materials for co-worker and being hit by penetrating or misplaced nail;
- awkward work in rafters, shooting back towards self;
- ricochets or penetrations caused by knots in wood;
- adjusting depth gauge of trim nailer with hand over nose piece;
- and eye injury from a piece of nail that broke off.

Nailing surfaces associated with contact trip injuries were identified and relevant, in 40 cases. In 72.5 percent of the cases, the carpenter was through nailing, followed by flat nailing in 20 percent of cases, and toenailing in 7 .5 percent of cases. The circumstances surrounding the injuries associated with tools with contact trip mechanisms included:

- rapid double fires of the tools, including being shot by co-worker who rapidly double shot gun;
- hitting body part with nose of tool when trigger was already depressed or locked in firing position;
- ricochet of nails off materials being nailed including very dense laminated beams;
- penetration of the surface being nailed;
- awkward hand position and tool placement, including working up in trusses shooting back towards self;
- use of non-dominant hand, resulting in poor control of tool;
- and reported tool malfunction (possibly rapid double fire).

While not always the sole contributing factor, in 30 cases — 63.8 percent of the injuries from guns with contact trip triggers and 43.5 percent of injuries overall— a sequential trigger would likely have prevented the injury.

The majority of injuries involved puncture wounds to the hand or fmgers, but should not be assumed to be insignificant injuries. There were several fractures; one injury resulted in a lengthy hospitalization for treatment of a wound infection, and half of these men lost time from work.

Injuries associated with nail guns could be significantly reduced through training, engineering, and policy changes in the workplace and manufacturing arena. The use of these tools cannot be assumed to be an unskilled task; workers need to know how to properly use the tool including how to safely position the tool and their bodies to prevent injury to themselves and co-workers. Training should include instruction on how to safely load, clean and maintain the tools. Workers should be aware of circumstances that are associated with inadvertent penetrations or ricochets including knots in wood, presence of other nails or metal truss components, and nailing into some of the newer, dense manufactured materials such as laminated beams and joists. Malfunctioning tools should be removed from service immediately. Training and workplace policy need to address the use of appropriate eye protection when using these tools, and appropriate practices must be in place to prevent dropping tools on workers below.

Use of sequential triggers would decrease acute injury rates markedly. Sequential triggers come on some, or can be installed on, new tools as well as being retrofitted on older tools, often at no cost. However, the sequential trigger is still not the industry standard. Workers do not typically purchase these tools; contractors who do must be part of the solution. Contractors have voiced concern over raising risks for repetitive trauma by requiring the use of sequential triggering tools and this fear should be evaluated; however, we saw few injuries of a cumulative nature compared to acute injuries making us question whether this fear is well-founded.

From the SLIPP data, there appear to be some situations, or tasks, that are better suited for the use of a hammer and nails, for example, when the individual has to be in awkward positions where the heavy gun and trailing hose create hazards for falling. Nailing in trusses is one example. There are also situations where the use of a nail gun really helps; rapid, secure placement of a nail can prevent creeping of materials, and the tool speed up productivity for sheathing, particularly.

The vast majority of injuries were associated with through nailing tasks, such as nailing studs or blocks, trusses or joists, as opposed to flat nailing used for sheathing activities. This provides some indication that contact trip tools could be safely used for flat nailing tasks. However, from an organizational standpoint, it is questionable whether tools would truly be designated for certain tasks based on the triggering mechanism; and there are dangers associated with contact trip tools, including carrying them with a finger on the trigger, that have nothing to do with specific nailing tasks. We are unaware of any reports evaluating the accuracy of rapid fire nailing. If nails do not hit the target, construction quality suffers, and unnecessary numbers of nails may be used, offsetting productivity gains from rapid-fire contact trip tools.

Key Points:

- Nail guns are responsible for an estimated 13 percent of injuries among residential carpenters.
- Nail guns are the single greatest cause of struck by injuries among residential carpenters, responsible for 20 percent of these injuries.
- Injury rates are 3.5 times greater among apprentice carpenters than journeymen, likely due to greater exposure to these tools and inexperience.
- Sequential triggers could prevent over 60% of injuries associated with contact trip guns.
- Nail guns, with trailing pneumatic hoses, should not be used in trusses and rafters where the work is awkward and fall hazards are magnified by their use.
- Prevention should involve training, engineering and policy changes; all should involve carpenters and contractors.

SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The National Institute funds the project for Occupational Safety and Health (N1OSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314)8671563; and Denny Patterson (618) 939-3481).

St. Louis Prevention Project-SLIPP

by HESTER LIPSCOMB,
ASSOCIATE PROFESSOR, DUKE UNIVERSITY MEDICAL CENTER
James Nolan, Local 2119 • Denny Patterson, Local 1310

LEARNING FROM BAD FALLS

Falls from elevated work surfaces are the leading cause of death and serious injury among carpenters. By sharing information we have collected from carpenters on several falls that occurred in the last few months, we hope others may be prevented.

In the first case, a carpenter was working 15 feet up on a patent scaffold that had been in place for several months. Planks were in place across the scaffolding with plywood over the top, creating the work surface. The man had been on the scaffold working without problem. Guardrails and handrails were in place. As he walked across the surface, the surface collapsed. The planking, beneath the plywood, extended four inches over the scaffold rails. As the man worked the planking had pulled loose, allowing him to fall 15 feet to the ground.

The next fall involved a man who was sheathing a wall and putting Tyvek Paper on it while it was laying on the subfloor. The roll was 10 feet wide and he was rolling it out on the wall, walking backwards. There was an opening in the floor where the fireplace was going to come up. The carpenter stepped back in to the hole, hit his head on the concrete wall and fell 14 feet into the basement. The carpenter's hardhat stayed on, likely preventing a more serious injury.

In the case of the third injury, a crane was being used to set a front porch beam. The carpenter was up on an aluminum straight ladder, leaning against the post, holding up the beam. He was up about eight feet on the ladder with a hammer in one hand and the 14' 2" x 4" in the other hand--he was going to use the 2" x 4" for a brace. The post kicked out at the bottom, causing the ladder to slip, and he fell eight feet.

All three of these incidents resulted in lost time from work. These examples provide lessons to be learned and clear guidelines to work by that could prevent these from happening again.

- **Always inspect scaffolding before you get on it.** This should include looking underneath the platform to see how the planking and platform are secured. You cannot assume a scaffold is safe because you worked on it the day before, or a few weeks before, without mishap.
- **Cover openings.** People think they won't fall through openings, but they do. You are busy. You forget what is behind you. You are often working with materials in your hands that obstruct your view.
- **Do not work/walk backwards.** You can easily fall into a trap that way. You need to be able to see where you are going.
- **Set and secure ladders.** Be sure you have the right ladder for the task at hand. Be sure the surfaces you set a ladder against are secure.
- **Any time you are working at an elevation, take the time you need to be safe.** You work hard and take pride in doing your job quickly and effiecently, but speed can kill.

••• SLIPP is a four-year project designed to identify measures to prevent injuries to carpenters who do residential or dry-wall work. This is a joint project between The Carpenters' District Council of Greater St. Louis and Vicinity, The Home Builders Association (HBA) of Greater St. Louis, affiliated drywall contractors, The Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medicial Center and N.C. State University. The project is funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome any comments, suggestions, or questions at anytime. Let us know what you think. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan at (314) 867-1563; and Denny Patterson at (618) 939-3481.)

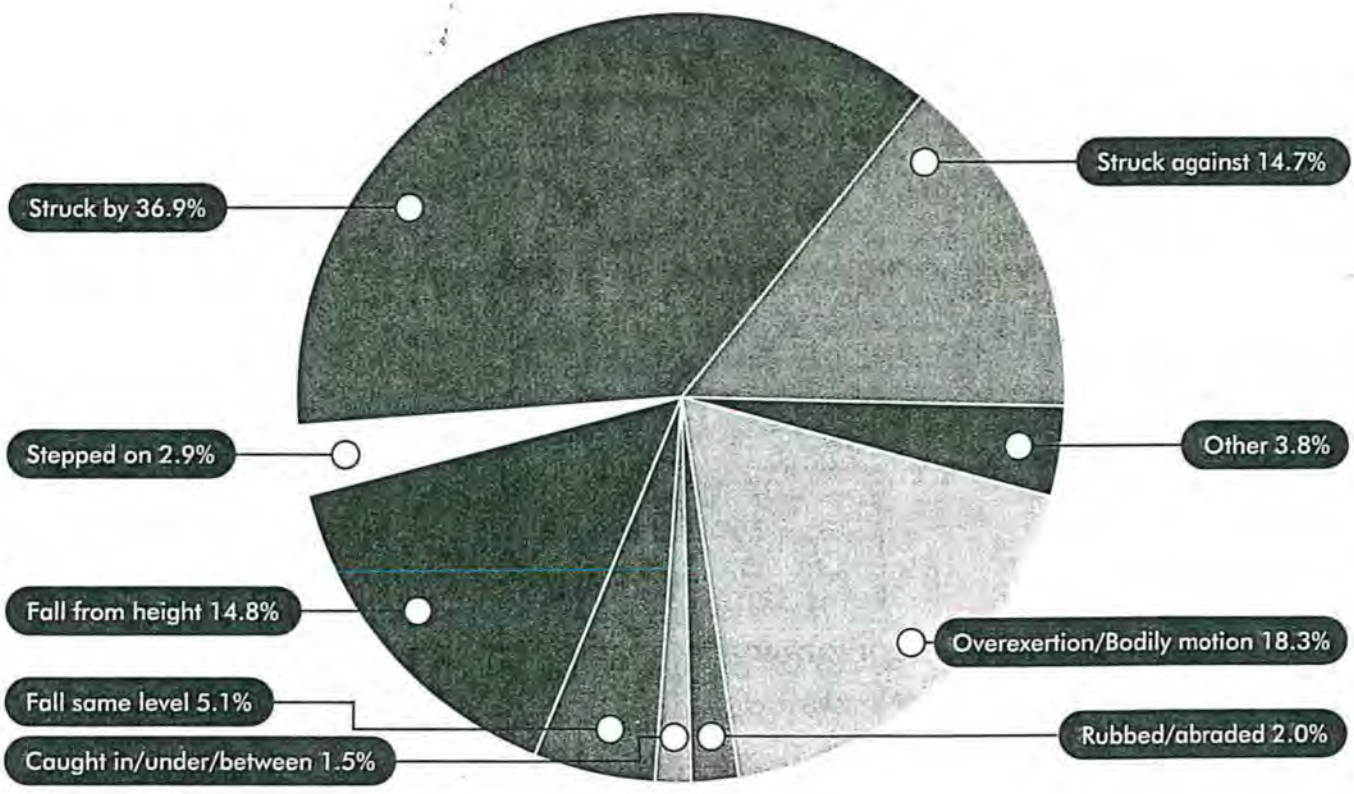
St. Louis Injury Prevention Project (SLIPP*)

Jim Nolan, Local 2119
Denny Patterson, Local 1310
Hester Lipscomb, Ph.D., Associate Professor, Duke University Medical Center

Final Interviews Conducted and Data Collected

The last injury reports for SLIPP were reported in September, and shortly after that we conducted the last injury investigation interviews. Since we began collecting information in September of 1999, 783 injuries were reported to the project office (this does not include 46 collected as a trial before we officially got the project underway). From those reports, 586 injured carpenters were interviewed about their injuries, and we were unable to reach 75 individuals. The overall participation rate was 75 percent; among those we actually reached, participation was 84 percent. This is a very impressive participation compared to many studies! This study, rather uniquely used carpenters to collect information from other carpenters, and the high participation likely represents injured carpenters being willing to talk with other carpenters about their injuries and experiences.

Below you will see the mechanism of the injuries we investigated. Nearly half of the injuries involved a carpenter being struck by or against something. The most common cause was from being struck by a nail from a pneumatic nail gun -- we have written about these injuries recently. The next most common injuries we saw were those caused by lifting, pushing, or pulling activities (overxertion) or injuries that just occurred in the course of work – walking and twisted an ankle, or bent over to get something (bodily motion).



The materials handling injuries often involved moving very heavy objects such as manufactured trusses or I-beams. Very few injuries were ascribed to cumulative trauma or repetitive motion and these were grouped under 'Other' in our chart with several other fairly rare injuries.

Falls accounted for just over 20 percent of all the injuries we investigated, and falls from a height were nearly 3 times as likely as falls from the same level. Falls from height occurred from loss of work surfaces and often could have been prevented by recognized fall prevention strategies – covering openings, guarding stairwells, using toe boards, using proper ladders, and careful inspection of scaffolds before use, for example. These injures were the most likely to result in devastating injuries.

Rates of injury, overall, were higher among apprentices, likely a reflection of inexperience -- but also different job responsibilities. However, over 45 percent of the injuries occurred among journeymen carpenters with 5 or more, years of experience so injury is not just caused by inexperience!

In the next few months, as we wrap up the final activities surrounding this project, we hope to provide opportunities for you to learn more details about the final analyses of these data. Some summaries are already on the District Council Website if you would like to take a look. We thank all of the contractors who agreed to report injuries to the project office, and we particularly thank the carpenters who agreed to share their experiences so someone else might benefit! The SLIPP crew wish all of you safety in the holiday season and beyond.

* SLIPP was a four-year project designed to identify measures to prevent injuries to carpenters who do residential or drywall work. This is a joint project of the Carpenters' District Council of Greater St. Louis, the Home Builders Association of Greater St. Louis, affiliated drywall contractors, the Center to Protect Workers' Rights (AFL-CIO) and researchers from Duke University Medical Center and N.C. State University. The project was funded by the National Institute for Occupational Safety and Health (NIOSH). We welcome your comments, suggestions, or questions at anytime. Feel free to call any of us. (Hester Lipscomb at (919) 286-1722, Ext. 256; Jim Nolan (314) 867-1563; and Denny Patterson (618) 939-3481).

SLIPP ALERT

Saint Louis Injury Prevention Project

Recent problems with heat

We wanted to alert you to recent heat related problems on job sites that have been reported through SLIPP. In the last wave of data collection 5 carpenters had heat related problems while working. All of these resolved, although care in the emergency room with intravenous fluids was required in some cases. In one case a carpenter lost consciousness. A worker who faints on the job because of heat may experience devastating injuries as well as their heat related problems. Loss of consciousness while working on a roof or ladder or operating power tools or helping others with a complex task could be devastating! In addition, to these directly heat related events, a number of summer injuries appear to have been related to heat and fatigue.

Heat can cause very severe problems as we are all aware after the publicity this summer following the death of a professional football player from heat stroke. Construction tasks are known to generate significant body heat even under normal conditions. Hopefully the intense summer heat in the St. Louis area will be letting up, but it is likely that there are still a number of very hot days ahead. Be sure foremen, and all crew members, are aware of basic things that can prevent problems related to heat as well as basic first aid measures for heat exhaustion. These simple measures can prevent devastating outcomes.

- Always have fluids, preferably Gatoraid type drinks, readily available on job sites.
- Insist that everybody take regular fluid breaks. **Do not rely on thirst to signal the need for fluids!**
- Do not allow people to work to the point of fatigue in the heat.
- Work earlier hours and/or shorter hours on very hot days to avoid exposure to intense heat.

In the event of any question about heat related problems, always be cautious.

- **Never hesitate to call 911 for a worker in trouble.** A quick response can make a huge difference in the outcome.
- Move the affected person to a shaded area.
- Have them lie down to maximize blood flow to the brain.
- If they are conscious, have them drink fluids.
- Application of cool water, damp towels or ice will help lower body temperature.

Summer 2001

Appendix D

Carpenter Magazine
Article, January 2003

SLIPP Works to Prevent Falls And Other Job Site Accidents

DON'T call them ACCIDENTS!!

KRISTI WHITE

Missouri got its nickname—"The Show Me State"—because folks there are a common-sense lot for whom actions speak louder than words. The Carpenters District Council of St. Louis and Vicinity is living up to that challenge by participating in an innovative study aimed at reducing the number of workplace injuries that befall carpenters.

With jobs that require the use of sharp, powerful tools—frequently far above ground—it's no surprise to the carpenters who live it every day that the federal government pegs construction work as the eighth most dangerous occupation in the nation.

Since its founding, the United Brotherhood of Carpenters has worked to improve workplace safety for carpenters by pursuing such innovations as the eight-hour day, unequaled training programs, and partnering with government to write safety regulations with teeth.

That commitment continues in Missouri with the union's involvement in the St. Louis Injury Prevention Project, or SLIPP.

Hester Lipscomb, an associate professor at Duke University Medical Center, heads the project and works with a team of researchers that includes carpenters. The ongoing effort seeks to get to the root of the causes of workplace injuries to carpenters doing residential and drywall work.

"What we're trying to do is document the kinds of injuries carpenters sustain, and to look at things that can be done to prevent these work site injuries," Lipscomb says.

To collect data, SLIPP researchers are interviewing hundreds of injured workers—all members of the UBC District Council of St. Louis and Vicinity.

What sets SLIPP apart from previous workplace injury studies is that rather than having traditional medical researchers doing the interviews, journeymen carpenters handle the job.

SLIPP researchers boast an 80 percent participation rate among injured carpenters, far above the norm in this kind of study.

Two big reasons for this high participation rate are: UBC members Jim Nolan, with 42 years of carpentry experience, and Dennis Patterson, with 25 years of experience, who conduct the interviews.

According to Lipscomb, the comfort level created by doing the interviews carpenter to carpenter gives a big boost to the study.

"We've had extremely good participation during the project, and I really believe that is because the injured carpenters are being interviewed by their peers," Lipscomb says. "Denny and Jim are able to establish rapport with their union colleagues quickly; the injured carpenters trust them."

Researchers who have conducted similar workplace studies know how difficult studying construction workers can be. They perform a variety of tasks, and at different job sites—often with only a few carpenters per site, and the conditions constantly change as the work progresses.

In almost three full years of data collection, Nolan and Patterson, both members of District Council of St. Louis and Vicinity, have interviewed nearly 700 union carpenters who have been injured on the job.

"We never refer to these incidents as 'accidents.' I was reprimanded for making that mistake early on in the project—that implies that the injuries 'are just something that happens'. They're not accidents...almost every one of these incidents can be prevented," Nolan says. "That's what we're working toward. After all, the name of this study is the St. Louis Injury PREVENTION Project."

Patterson concurs, adding that experience helps make for safer workers.

"We're finding that a lot more apprentices are suffering particular types of injuries, as opposed to journeymen," Patterson says. "So, experience is a big factor for some types of injuries particularly. Experience is one reason a lot of guys don't get hurt."

That does not mean, however, that all new carpenters must enroll at the school of hard knocks.

"Apprentices should not have to expect to be hurt as they gain experience; we need to learn how to prevent injuries of inexperience as well", says Lipscomb.

An interesting example comes from one of the first patterns the team noticed in its work. Lipscomb explains that when the carpenter researchers began interviewing injured workers in August 1999, almost immediately they began to see injuries from pneumatic nail guns.

"Early on when we started collecting data, we began to see injuries in which carpenters either shot themselves or injured a co-worker," Lipscomb says.

"Until I participated in this project, I had no idea these nail guns were so dan-

(Continued on page 17.)

SLIPP TIPS

These are some workplace-safety tips recommended by the St. Louis Injury Prevention Project. They originally appeared in longer form in The Cutting Edge, the official publication of the Carpenters District Council of St. Louis and Vicinity.

Problems With Heat

Heat can cause severe health problems, as last year's death of professional football star Korey Stringer showed. Construction tasks generate significant body heat, even under normal conditions, so all crew members need to be able to avoid heat problems and offer first aid should they arise.

Workers who faint on the job because of heat may experience devastating injuries as well. Loss of consciousness while working on a roof or ladder or operating power tools or helping others with a complex task could be serious.

Here are some ways to avoid problems:

- Always have fluids available.
- Insist that everybody take regular fluid breaks. Do not rely on thirst to signal the need for fluids.
- When possible, avoid working in the heat of the day.

Should trouble arise:

- Never hesitate to call 911 for a worker in trouble. A quick response can make a huge difference.
- Move the injured to a shaded area.
- Have them lie down and drink fluids if conscious.
- Application of cool water, damp towels or ice will help lower body temperature.

Ladders

Work on ladders is likely second nature to carpenters, yet these devices present significant fall hazards to construction workers.

Although many workers in multiple trades work on ladders, construction workers are responsible for nearly half of all falls from ladders that result in fatalities in the U.S. each year.

Here are some commonsense precautions to take when using ladders:

- Inspect them for structural damage, missing or damaged safety devices, grease or grime that might create a slip hazard.
- Wear slip-resistant shoes that are not muddy.
- Keep the area around the ladder clear at the top and the bottom.
- Use a hoist or pulley for heavy or awkward materials—do not carry them up or down a ladder.
- Keep both hands free for climbing.
- Face the ladder and maintain three-point contact (two hands and one foot or two feet and one hand).
- Don't load the ladder beyond its maximum intended load—know the manufacturer's recommendations. The table below summarizes maximum working loads for different types of ladders—the load includes the weight of the user, materials, and tools.

Type	Duty	Duty Rating
Type IA	Extra heavy	300 pounds
Type I	Heavy	250 pounds
Type II	Medium	225 pounds
Type III	Light	200 pounds

- Use stepladders only on stable, solid surfaces, making sure they are fully extended and spreaders are locked.
- Never climb or stand on leg braces, top step or tray.
- When using extension ladders or straight ladders, make sure they're on stable and level surfaces unless secured to prevent the ladder from slipping or falling.
- Extend ladder rails at least 3 feet above the upper landing
- Use 4:1 ratio to set the ladder, placing the ladder out one foot for every four feet of height.
- Set the ladder so both rails maintain contact with the supporting structure.
- Use adjustable feet to level the ladder if needed.
- Never lean more than 12 inches beyond either rail. Remember the belt-buckle rule: Always keep your belt buckle inside the side rails of the ladder.
- The third-highest rung is the maximum climbing height.

Raising walls

There are things carpenters do every day that have the potential to be very dangerous despite being part of a regular routine.

Framing walls is an example. Walls get framed, raised, and braced thousands of times a day and most of the time no one gets hurt, yet this task involves a number of potentially dangerous steps or activities.

We have seen a number of injuries associated with this task. Some involved injuries to the back or shoulders from lifting; sometimes caused by one person dropping their load and shifting weight to others unexpectedly. We also have seen a number of injuries caused by walls falling as they were being lifted.

A framed wall can weigh several hundred pounds and requires several men to raise. As the wall is lifted from the floor and pushed into position, it not only requires significant effort but also coordination of the team doing the work.

Some tips:

- Use assistive devices whenever possible to help with the load, but they require precautions as well.
- Two-by-four blocks can be placed under heavy walls with a crowbar to allow everyone a good handhold.
- Using sawhorses to place the wall on after it is lifted from the floor but before it is pushed up can allow time to change grips and take a break,
- Remember the power of wind. On a windy day walls that have been propped up can get blown over if not braced.

The Carpenters District Council in St. Louis has already posted a series of summary reports from the SLIPP study on its website at www.carpdc.org/slipp

La UBC Está Dedicada a Mantener la Seguridad de los Carpinteros


KRISTI WHITE

Desde que fue fundada, la Hermandad Unida de Carpinteros (UBC) ha trabajado arduamente para mejorar la seguridad de los carpinteros en el sitio de trabajo a través del logro de innovaciones tales como la jornada de trabajo de ocho horas, programas de capacitación únicos y trabajando con el gobierno para redactar reglamentaciones de seguridad en el sitio de trabajo que sean vigorosas y adecuadas.

Hoy en día ese compromiso continúa inalterado como lo demuestra el Consejo Distrital de Carpinteros del Área Metropolitana de la ciudad de St. Louis, el cual está participando en un novedoso estudio que tiene por objetivo la reducción del número de accidentes en el sitio de trabajo que afectan a los carpinteros.

Hester Lipscomb, un profesor asociado del Centro Médico de la Universidad Duke, dirige el Proyecto para la Prevención de Lesiones y Heridas en la ciudad de St. Louis y trabaja con un equipo de investigadores que incluye a varios carpinteros. El esfuerzo actualmente en marcha busca como llegar a la raíz de las causas de lesiones que ocurren en el sitio de trabajo afectando a carpinteros envueltos en trabajo residencial y con paneles de yeso (drywall).

"Lo que estamos tratando de hacer es documentar todo tipo de lesiones y heridas sufridas por carpinteros y determinar lo que se puede hacer para prevenir estas lesiones en el sitio de trabajo" afirma el Sr. Lipscomb.

Lo que distingue al proyecto de St. Louis de otros estudios de lesiones que ocurren en el sitio de trabajo es que las entrevistas anteriormente hechas por investigadores médicos tradicionales, ahora las mismas son realizadas por carpinteros de oficio.

Los investigadores en St. Louis se jactan de que obtienen un 80% de participación por parte de los carpinteros lesionados, cuyo porcentaje sobrepasa los niveles normalmente obtenidos en este tipo de estudio.

Existen dos razones en particular por este alto nivel de participación: dos carpinteros de la UBC, Jim Nolan, con 42 años de experiencia en carpintería y Dennis Patterson con 25 años de experiencia, quienes son responsables por conducir las entrevistas.

Según Lipscomb, el nivel de conforto que se crea al conducir las entrevistas de carpintero a carpintero le ha dado un enorme empuje al éxito del estudio.

"Nosotros hemos tenido una participación extremadamente buena durante el proyecto, y yo realmente creo que ésto se debe a que los carpinteros lesionados están

UN CONSEJO SALUDABLE

Estos son algunos de los puntos sobre la seguridad en el lugar de trabajo que son recomendados por el Proyecto para la Prevención de Lesiones y Heridas en St. Louis. Originalmente estos puntos aparecieron en forma más detallada en The Cutting Edge, la publicación oficial del Consejo Distrital de Carpinteros del Área Metropolitana de la Ciudad de St. Louis.

Problemas con el Calor

El calor puede causar severos problemas de salud, como fue demostrado por la muerte el año pasado del futbolista profesional Korey Stringer. Las tareas de la industria de la construcción generan un aumento significativo en la temperatura del cuerpo, aun bajo condiciones normales, de modo que todos los miembros de un equipo de trabajo deben de poder evitar problemas relacionados con el calor y ofrecer primeros auxilios si éstos ocurrieran.

Trabajadores que se desmayan en el lugar de empleo por razones de la alta temperatura también pueden sufrir lesiones devastadoras. Una pérdida del conocimiento mientras que están trabajando en un techo, o en una escalera u operando herramientas de poder eléctrico, o mientras ayudan a otros con una tarea complicada podría ser devastadora para tales trabajadores.

Aquí se listan algunas sugerencias para evitar problemas:

- Siempre tenga líquidos disponibles
- Insista que todos tomen descansos regulares para tomar líquidos. No espere que le de sed como una señal de que necesita líquidos.
- Cuando sea posible, evite trabajar cuando la temperatura durante el día llegue a un nivel muy alto.

Escaleras

El trabajo en escaleras es una cosa muy común para los carpinteros, sin embargo estos aparatos presentan altos riegos de caídas para los trabajadores en construcción.

Aunque muchos trabajadores en múltiples oficios trabajan en escaleras, los trabajadores de la construcción son responsables por casi una mitad del total de todas las caídas de escaleras que resultan en fatalidades en los EE.UU. cada año.

Aquí se listan unas precauciones de sentido común que debe tomar cuando use escaleras:

- Inspeccione la escalera para determinar posibles daños estructurales, aparatos de seguridad que faltan o que están dañados, grasa o mugre en la escalera que puedan causar un riesgo de resbalarse.
- Use zapatos que resistan resbalones y que no estén llenos de lodo.
- Mire de frente a la escalera y mantenga un contacto de tres puntos (las dos manos y un pie o los dos pies y una mano)

KRISTI WHITE

siendo entrevistados por sus propios compañeros," dice Lipscomb.

En casi tres años completos de llevar adelante la colección de datos, Nolan y Patterson, ambos miembros del Consejo Distrital del Área Metropolitana de la Ciudad de St. Louis, han entrevistado a casi 700 carpinteros sindicalizados que han sido lesionados en el sitio de trabajo.

"Nunca nos referimos a estos incidentes como 'accidentes'. Me llamaron la atención por cometer ese error cuando empezamos el proyecto -- esto implica que las lesiones y heridas 'solamente son algo que ocurre'. No son accidentes . . .ya que casi cada uno de estos incidentes pueden ser prevenidos," dice Nolan. "Este es el fin a lo que queremos llegar. Después de todo, el nombre de este estudio es el Proyecto para la PREVENCIÓN de Lesiones y Heridas en St. Louis."

El proyecto de cuatro años está financiado por una donación de $750,000 hecha por el Instituto Nacional para la Seguridad y Salud Ocupacional. Los investigadores completaron su colección de datos a fines de septiembre y ellos pasaran los próximos meses analizando la información. Los resultados eventualmente serán publicados en periódicos académicos y de asociaciones comerciales. ■

El profesor Hester Lipscomb del Centro Médico de la Universidad Duke comunica sus observaciones al supervisor de construcción Kenneth Baker del Sindicato Local 1839 sobre las prácticas de seguridad de los trabajadores de una subdivisión de viviendas que se está construyendo en Spanish Lake, Mo. A la izquierda se encuentra Denny Pattterson del Sindicato Local 1310 de Trabajadores de la Construcción de Pisos y a la derecha está Jim Nolan del Sindicato Local 219. Patterson y Nolan, carpinteros de oficio, trabajaron como investigadores en un extensivo proyecto para la prevención de accidentes liderado por Lipscomb.

(Continued from page 15.)

gerous," Nolan says. "I've worked 42 years with a hammer. Now pneumatic nail guns have become common tools used in residential construction. I didn't even know the difference between a sequential and contract trip.

"Some of these guns have the capability of firing nine or 10 shots a second," Nolan says. "If a guy can bounce it that fast, it's like operating like a machine gun. I've seen cases where a guy walks around (a jobsite) with his finger on the trigger and he bumps his thigh and it triggers the gun. When that happens, he shoots a 3_-inch nail into his thigh."

Patterson is more succinct: "Well, it has the word 'gun' in the title. For this reason alone, it's a dangerous tool."

The researchers have learned that a lack of training frequently contributes to nail gun injuries.

"The data do show that we have a lot more apprentices being injured with nail guns as opposed to journeymen," Patterson says. "So, proper training and experience comes into play. Experience is one thing that will help prevent an injury."

Falls are another type of injury that has been seen too frequently by the researchers—and these injuries tend to be much more serious.

"Our guys are falling from ladders and scaffolds. They're falling through holes cut in roofs, falling from windows—they're falling off everything," Nolan says.

There are certainly challenges to fall protection in residential construction, but Patterson notes that use of proper equipment and safety practices are enough to prevent many falls.

"A number of things are important," Lipscomb says. "Using the right ladder for the job is crucially important. The ladder should be the right length. A worker shouldn't use a stepladder when he needs an extension ladder. And workers need to know how to set the ladder up safely."

These are not just injuries of inexperience. Surprisingly, the researchers have learned that even experienced workers suffer falls. Indeed, among carpenters who have suffered falls on the jobs, half have been UBC members for at least four years.

Based on the number of falls reported to the SLIPP, Lipscomb estimates that among 200 apprentice residential carpenters working 2,000 hours in a year, on average six will experience a fall from a height. Similarly, among 200 journeymen, she estimates that three will fall each year.

Nolan believes that overall, many injuries occur when young workers shoulder more than they can handle.

"There are so many young fellows who don't get the proper training on the job, and a lot of this stuff you learn from proper training and experience," Nolan says. "I think a lot of the problems come from guys trying to do too much.

"If you think about what you're doing and don't rush things, you cut down your risk of injuries by a tremendous amount," he says.

SLIPP is a joint project of the Carpenters District Council of St. Louis and Vicinity, the Home Builders Association of Greater St. Louis, a group of unionized drywall contractors, the AFL-CIO's Center to Protect Workers Rights and researchers from Duke University Medical Center and North Carolina State University. The four-year project is funded by a $750,000 grant from the National Institute for Occupational Safety and Health.

The research team finished collecting data at the end of September and they will spend the next several months analyzing the information. Findings will be reported to the CDC in St. Louis and the contractors who participated, to the National Institute for Occupational Safety and Health that funded the work, and in academic and trade journals. ■

Duke University Medical Center Associate Professor Hester Lipscomb discusses with construction supervisor Kenneth Baker of Local 1839 her observations of safety practices of workers on a housing subdivision going up in Spanish Lake, Mo. At left is Denny Patterson of Floor Layers Local 1310 and at right is Jim Nolan of Local 219. Patterson and Nolan worked as journeymen investigators in an extensive accident-prevention project headed by Lipscomb.