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# Work-Related Injuries in Residential and Drywall Carpentry

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**Findings are reported on the first two years of an active injury surveillance project designed to test the utility of active injury investigations in identifying causes of injury among a large cohort of carpenters who did residential building and drywall installation. Occupational Safety and Health Administration recordable injuries were reported by participating contractors. Injured union carpenters were interviewed by experienced journeymen trained in a standard questionnaire protocol. Enumeration of workers and hours worked were provided by the union. These data allowed the definition of a dynamic cohort of 4429 carpenters, their hours worked, detailed information on the circumstances surrounding recordable injuries, and possible preventive measures from the perspectives of the injured worker and an experienced journeyman investigator.**

**The overall estimated injury rate (16.9 per 200,000 hours worked) was considerably higher than recent Bureau of Labor Statistics rates despite less than complete ascertainment of injuries. Injuries most commonly involved being struck by or against something, manual materials handling injuries, and falls. Manual materials handling injuries often involved very heavy objects or tasks and were injuries carpenters most often reported needs for adequate help and coordinated team work to prevent. Falls from heights occurred from a variety of surfaces and were not just injuries of inexperience. Carpenters reported the need for more attention to common fall protection practices, such as the use of more toe boards and guardrails. Poor housekeeping was involved in the majority of same level falls, as well as some manual materials handling injuries.**

**Keywords** Active Surveillance, Injury, Residential Construction, Carpentry, Drywall

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.[1] Fatal and lost work time injuries in the construction trades continue to rank among the highest in the United States,[2–6] and national rates of disabling injuries have risen in recent decades.[7]

Information on the etiology of work-related injuries among construction workers has been limited by practical problems that make the study of their health and safety hazards difficult. These are especially salient when considering those who do residential and drywall work. In residential construction, particularly, the duration of work at any given site is typically shorter in nature than in commercial construction and the nature of the work changes from day to day. Job sites are typically small, with fewer workers at any given site. 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,[8–11] including high workers' compensation premiums in both of these areas of the trade.[12]

Findings are reported on the first two years of 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 carpenters doing residential building and drywall installation. The program was designed to document the magnitude of injuries among these carpenters and to describe in detail the nature of their injuries and the circumstances surrounding these events.

## MATERIALS AND METHODS

### Site of Work

This active injury surveillance project was conducted in St. Louis, Missouri, with members of the United Brotherhood

of Carpenters and Joiners of North America. Union carpenters are involved in a wide variety of types of construction including light and heavy commercial work, pile driving, millwrighting, residential building, and drywall installation on both residential and commercial sites. St. Louis 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. Participating contractors agreed to report all Occupational Safety and Health Administration (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 as they occurred.

### Investigation Methods

The surveillance approach was modeled after the National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment Control and Evaluation (FACE) program. In contrast to FACE, the primary focus was the bulk of work-related injuries that do not result in death. Injured carpenters were interviewed by one of two experienced journeymen. These men had, respectively, 42 and 25 years of carpentry experience and OSHA 500 safety training specific to the construction industry. They were trained in procedures to obtain informed consent and the administration of a standard questionnaire for investigation of these injuries.

The questionnaire was developed with input from a steering committee established early in the project with representation from the union, contractors, contractors' safety personnel, and the academic research team. Questions were included about the nature and circumstances surrounding the injury, 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, in his opinion, caused or contributed to the injury. More specific questions were asked for the more common types of construction injuries including those in which a worker is struck by or against something, manual materials handling or overexertion injuries, falls, and eye injuries. The tool was pretested in the field for three months with review of all findings by the interviewers and the research team.

As injuries were reported, the injured worker was approached about participation. After informed consent was obtained, interviews were typically conducted by phone. After the interview, the investigating carpenter also reported his assessment of contributing factors and preventive recommendations.

### 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 they hire. The local trust provided the hours worked for each carpenter by contractor for each month, allowing the calculation of time at risk.

### Nature of Data and Management

The interview data consisted of closed ended responses and text information describing the circumstances and preventive suggestions. All data were entered into an ACCESS[13] relational database. Codes were assigned for body part, nature, and mechanism of injury using modified American National Standards Institute (ANSI) categories common to workers' compensation data. In the first year, records were entered and verified by different individuals with few discrepancies. After this period, all text entries were checked for accuracy, and frequencies of categorical data were run in SAS (version 8) for quality control purposes monthly.

### Analyses

Descriptive statistics were generated for the coded variables from the worker interviews and for the age, gender, and union status of the cohort. Union carpenters typically spend four years in an apprenticeship, which combines regular periods of classroom and supervised shop training with their work on construction sites. The sum of hours worked by the cohort between September 1, 1999, and November 30, 2001, was calculated; hours were also stratified by union status. Injury rates were calculated per 200,000 hours worked. Overall rates were calculated using all reported injuries; stratified rates and rate ratios,[14] dependent on information from the interview, were limited to data from participating carpenters. Confidence intervals (95%) were calculated as described by Haenszel et al., assuming a Poisson distribution.[15]

Records were sorted by mechanism of injury (fall, manual materials handling). Text descriptions were reviewed to identify 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[13] queries and export of data to SAS (version 8).[16]

## RESULTS

### Description of the Cohort and Hours Worked

The study cohort consisted of 4429 union carpenters who worked for one of the 20 participating contractors; they hired a total of 7,108,594 union carpenter hours during this 27-month period of time. There were 902 carpenters who worked for drywall companies contributing 1,183,599 hours of the total. In this area, union carpenters hang, but do not finish, drywall on commercial and residential sites. Ages ranged from 18–71 years (mean 33.1 years, median 32); time in the union ranged from less than one year to 39 years (mean 8.2 years, median 4 years). Less than one percent ($n = 13$) of the carpenters were women.

## Description of Injuries

During the first 27 months of data collection, 602 injuries were reported. Interviews were completed with 464 (77.1%) carpenters. Thirty-two individuals were unable to be reached, making the participation rate 81.4 percent among located carpenters. Interviews were conducted from the day of injury up to 202 days after injury (mean of 21 days, 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.

Three hundred twenty-three injuries occurred on residential single-family sites (69.5%), including three boathouses and one remodeling job, and 135 injuries occurred on residential multi-family or commercial drywall (29.0%) projects. For the remaining injuries no specific site was reported by the worker, including injuries ascribed to repetitive trauma that developed over time. Commercial drywall injuries accounted for 11 percent (n = 51) of the investigated injuries. The stages of the residential construction projects when the injuries occurred are presented in Table I. Over 60 percent of the residential injuries occurred in framing, followed by exterior finish (11.7%), and roofing (8.3%). Union carpenters perform roof sheathing, but not shingling.

The mechanism of the injuries are presented in Figure 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.

In Table II 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 (76%). Nearly 90 percent of the overexertion injuries resulted in sprains and strains. Falls from heights and same level falls most often resulted in sprains/strains or contusions, but 22 percent and 20 percent of these falls, respectively, resulted in fractures. During this 27-month period, 13 cases were reported as being the result of repetitive activity. Injuries that resulted from being caught by something were similar to the struck

**TABLE I**
Stage of construction work–related injuries from active injury surveillance union residential[A] carpentry, 1999–2001

| | Frequency (percent) |
|---|---|
| Residential stage | |
| Groundbreaking/layout | 1 (0.0) |
| Foundation | 14 (3.5) |
| Framing | 245 (61.1) |
| Roofing[B] | 33 (8.2) |
| Interior finish, not drywall | 29 (7.2) |
| Drywall | 20 (5.0) |
| Exterior finish | 47 (11.7) |
| Remodel/demolition | 7 (1.7) |
| Punch list/final tasks | 5 (1.3) |
| Total | 401 (100.0) |

[A]Fifty-one (51) injuries in commercial interior finish (drywall) and 12 missing/unknown/or cumulative attribution are not included in the table.
[B]These residential carpenters do roof sheathing, not shingling.

**TABLE II**
Nature of injury by mechanism union residential and drywall carpentry, 1999–2001

| Mechanism of injury | Nature of injury | Frequency (percent) |
|---|---|---|
| Struck by or against | Cut | 97 (38.3) |
| | Puncture wound | 60 (23.7) |
| | Scratches/abrasions | 37 (14.6) |
| | Contusion | 28 (11.1) |
| | Eye foreign body | 11 (4.4) |
| | Fracture | 11 (4.4) |
| | Sprain/strain | 5 (2.0) |
| | Amputation | 2 (0.8) |
| | Others[A] | 2 (0.8) |
| | Total | 253 (100) |
| Overexertion | Sprain/strain | 75 (89.3) |
| | Hernia | 2 (2.4) |
| | Fracture | 2 (2.4) |
| | Torn cartilage/meniscus | 2 (2.4) |
| | Others[A] | 3 (3.6) |
| | Total | 84 ( 100) |
| Falls from height | Contusion | 22 (32.4) |
| | Sprain/strain | 21 (30.9) |
| | Fracture | 15 (22.1) |
| | Cut | 3 (4.4) |
| | Dislocation | 2 (2.9) |
| | Multiple injury | 2 (2.9) |
| | Concussion | 2 (2.9) |
| | Chipped tooth | 1 (1.5) |
| | Total | 68 (100) |
| Same level falls | Sprain/strain | 10 (40.0) |
| | Contusion | 8 (32.0) |
| | Fracture | 5 (20.0) |
| | Others[A] | 2 (8.0) |
| | Total | 25 (100) |
| Repetitive activity | Carpal tunnel syndrome | 5 (38.5) |
| | Ganglion cyst | 2 (15.4) |
| | Others[A] | 6 (46.2) |
| | Total | 13 (100) |
| Caught | Sprain/strain | 3 (42.9) |
| | Fracture | 2 (28.6) |
| | Others[A] | 2 (28.6) |
| | Total | 7 (100) |

Note: Heat-related, electric shock, and stings/bites are not included.
[A]Single observations only.

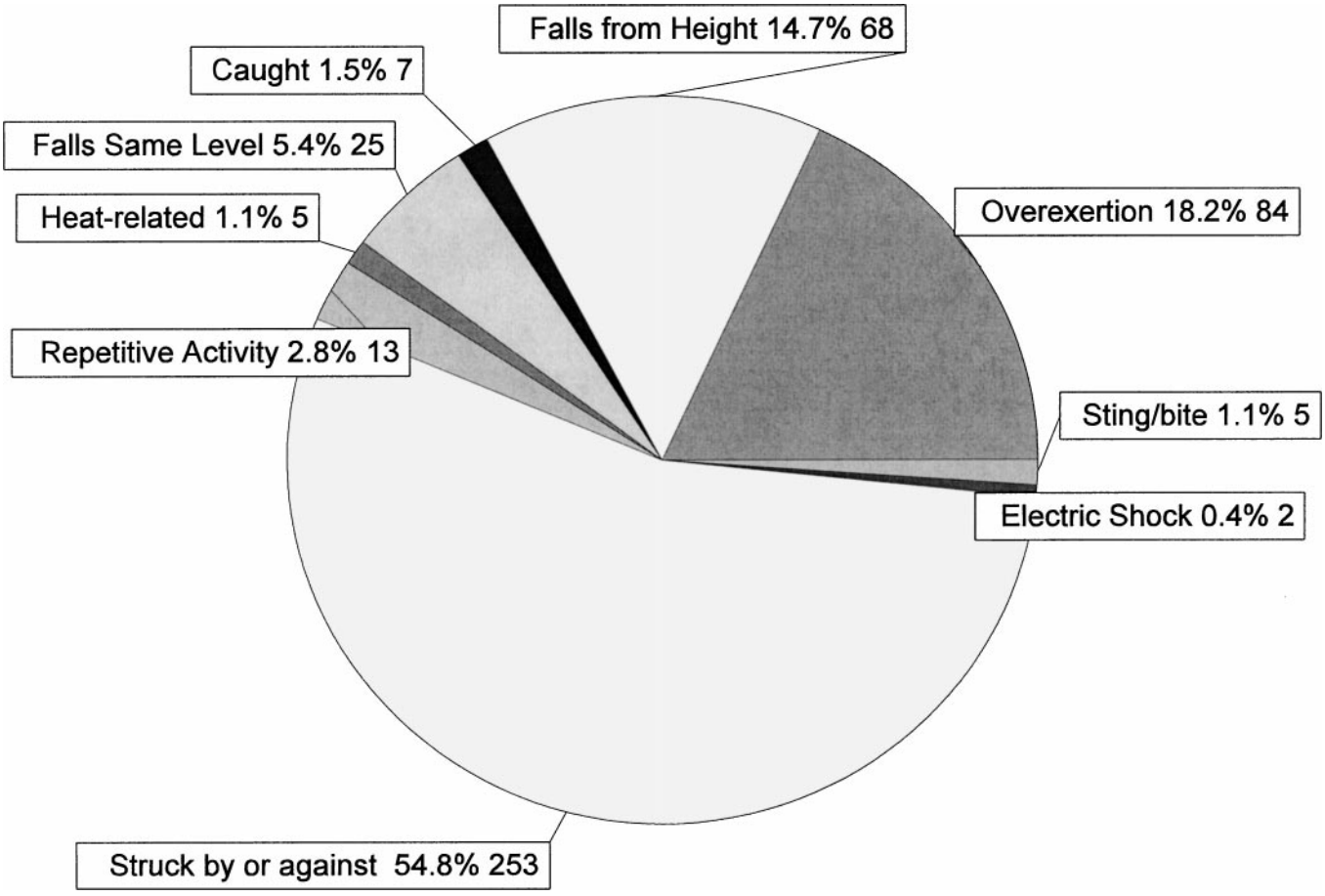


**FIGURE 1**
Distribution of mechanism of injury percent and frequencies. Active injury surveillance union residential and drywall carpentry, 1999–2001.

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 seven (28.6%) resulted in fractures.

The objects that carpenters were struck by or against are presented in Table III. The most common objects carpenters were struck by were nails or nail pieces (n = 62). The majority of these came from pneumatic nail guns (n = 52), resulting in puncture wounds and fractures. The next most common objects included dust and debris, which resulted in eye injuries, and power tools and metal band irons used to bundle materials on construction sites, which 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 were most commonly associated with handling of building materials (Table IV). For 67 of these objects weight was estimated; the carpenter was handling an object weighing greater than 100 pounds 36 percent of the time (n = 24) and 200 or more pounds 25 percent of the time (n = 17).

Over half the time when overexertion injuries occurred the person was working alone (n = 41). In only 14 cases (19%) was the load unexpected; but in 42 cases (53%) the carpenter reported working in an awkward posture when hurt.

Carpenters fell from a wide variety of surfaces, most commonly scaffolds and ladders (Table V). 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.

The work surfaces from which the carpenters fell were described as being covered with frost in five cases (7%), wet in 12 cases (n = 18%), and not secure in 10 cases (n = 15%). The distances fallen ranged from 2 to 25 feet (mean and median 9 feet). Equipment failure was reported to have contributed to the fall in 4 cases (6%), loss of balance in 39 cases (58%). Other falls were caused by unguarded openings including windows, stairwells, and openings in the sub-floor, and collapsing surfaces. In 28 cases (43%) the carpenter was working with tools when he fell, and in 26 cases he was handling materials (41%), including very heavy objects such as joists, drywall, pic boards

**TABLE III**
Objects carpenters were struck by or against union residential and drywall carpentry, 1999–2001

| | Frequency (percent) |
|---|---|
| Fasteners | |
| Nail/piece of nail | 62 (24.5) |
| Staples/screws | 7 (2.8) |
| Materials | |
| Boards (variety of sizes) | 12 (4.7) |
| Joist (includes para-microlam) | 7 (2.8) |
| I-beam, steel | 6 (2.4) |
| Plywood | 6 (2.4) |
| Others[A] | 2 (0.8) |
| Metal materials | |
| Band iron | 13 (5.1) |
| Framing track | 5 (2.0) |
| Metal stud | 5 (2.0) |
| Cornerbead | 4 (1.6) |
| Joist hanger | 2 (0.8) |
| Others[A] | 9 (3.6) |
| Equipment | |
| Ladder | 2 (0.8) |
| Bakers' scaffold | 1 (0.4) |
| Hand Tools | |
| Utility knife | 12 (4.7) |
| Hammer | 7 (2.8) |
| Sledgehammer | 1 (0.4) |
| Power Tools | |
| Power saws (blade) | 18 (7.1) |
| Others[A] | 5 (2.0) |
| Pre-constructed components | |
| Walls/partitions | 4 (1.6) |
| Cabinet/doors | 3 (1.2) |
| Others[A] | 2 (0.8) |
| Debris | |
| Sawdust/dirt/chips | 20 (7.9) |
| Splinters | 8 (3.2) |
| Metal shavings | 9 (3.6) |
| Miscellaneous others[A] | 21 (8.3) |
| Total | 253 (100) |

[A]Single observations only.

from ladder jacks, or sheets of plywood. In 34 cases (52%) the carpenter reported the availability of some fall protection equipment on site. Twenty-seven percent were working below 6 feet when they fell where fall protection is not required. Only one person reported using fall protection at the time of his fall; this one reported the presence of a guardrail.

Same level falls were almost exclusively related to 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, and difficult access and/or egress

**TABLE IV**
Objects associated with manual materials handling tasks union residential and drywall carpentry, 1999–2001

| | Frequency (percent) |
|---|---|
| Building materials | |
| Boards/lumber | 15 (20.8) |
| Trusses/joists (Includes laminated beams) | 13 (18.1) |
| Drywall sheets | 8 (11.1) |
| Steel I-beams | 6 (8.3) |
| Plywood sheets/particle board | 3 (4.2) |
| Doors | 3 (4.2) |
| Siding (masonite, vinyl) | 2 (2.8) |
| Trim/molding | 2 (2.8) |
| Bricks/blocks | 2 (2.8) |
| Box of nails | 1 (1.4) |
| Total | 55 (76.4) |
| Equipment | |
| Pic board (platform for ladder jack) | 5 (6.9) |
| Ladder (extension) | 3 (4.2) |
| Others | 2 (2.8) |
| Total | 10 (13.9) |
| Pre-constructed components | |
| Framed wall | 2 (2.8) |
| Vanity (oversized, marble) | 2 (2.8) |
| Others[A] | 3 (4.2) |
| Total | 7 (13.9) |
| Overall total | 72 (100.0) |

[A]Single observations only.

**TABLE V**
Surfaces from which carpenters fell from heights union residential and drywall carpentry, 1999–2001

| | Frequency (percent) |
|---|---|
| Scaffold | 15 (22.1) |
| Ladder | 10 (14.7) |
| Roof | 7 (10.3) |
| Through opening | 7 (10.3) |
| Joist | 6 (8.8) |
| Foundation wall | 6 (8.8) |
| Trusses/rafter | 4 (5.9) |
| Top plate of wall | 4 (5.9) |
| Stair | 3 (4.4) |
| Sub-floor | 3 (4.4) |
| Others[A] | 3 (4.4) |
| Total | 68 (100) |

[A]Single observations only.

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 onsite was reported by 262 (56.5%) of the injured workers, while 376 (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."

### 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 39 years (mean 8.2 years, median 4 years); 203 were apprentices and 261 were journeymen.

Reported awareness of onsite safety programs are presented in Table VI. Over 75 percent 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 (16.8 days vs. 10.7 days; $p = 0.07$), and they had worked for the contractor longer than those who were not aware of any safety program (mean 53.3 months vs. 26.6 months; $p < 0.0001$).

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

### Estimated Rates of Injury

The estimated overall injury rate was 16.9 per 200,000 hours worked (603/7.1 million hours). There were 227 injuries (49% of those interviewed) that resulted in lost time from work beyond the day of injury, representing a lost-time injury rate of 6.4 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 7.6 per 200,000 hours. The estimated rate of reported injuries in residential building was 15.4 per 200,000 hours worked (549/5.9 million). The rate of drywall injuries was 12.0 per 200,000 hours worked.

**TABLE VI**
Reported awareness of onsite safety program injured union residential and drywall carpenters, 1999–2001

| Awareness of onsite safety program | Frequency (percent)[A] 331 (75.4%) |
|---|---|
| Designated safety person | 290 (62.5%) |
| Hazard communication | 267 (57.5%) |
| Fall protection plan | 254 (54.7%) |
| Safety manual | 246 (53.0%) |

[A]Percent of those who responded to question.

**TABLE VII**
Reported availability of personal protective equipment injured union residential and drywall carpenters, 1999–2001

| PPE | Frequency (percent)[A] |
|---|---|
| Hard hats | 452 (92.3%) |
| Safety glasses or goggles | 419 (93.1%) |
| Guardrails | 397 (90.9%) |
| Safety belt/harness and/or lifelines | 249 (63.4%) |
| Ear plugs or other hearing protection | 262 (61.5%) |
| Gloves | 196 (41.3%) |
| Back belts | 60 (27.9%) |
| Aprons | 4 (3.4%) |

[A]Percent of those who responded to question.

The injury rate among apprentices was 17.7 per 200,000 hours worked (95% CI 15.4 to 20.4) compared to 11.1 per 200,000 hours worked (95% CI 9.6 to 12.6) among journeymen ($RR = 1.6$). Rates for the major mechanisms of injury are compared by union status in Table VIII. Rates were significantly higher among apprentices for injuries that resulted from being struck by or against something ($RR = 1.9$). Rates, particularly for the remaining categories, are based on small numbers resulting in wide confidence intervals.

### Prevention Recommendations of Workers and Journeymen Investigators

In Table IX, responses of injured carpenters to specific queries about contributions to their injuries are summarized. 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-four percent (44%) of workers who experienced a same level fall felt time pressures contributed to the circumstances leading to injury, and 20 percent attributed housekeeping issues. Overexertion injuries were most often attributed to the task being too heavy (33%) or the carpenter needing help (25%).

Although some carpenters ($n = 79$; 17%) 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 X. 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

**TABLE VIII**
Work-related injury rate[A] estimates for primary mechanisms of injury by union status active injury surveillance union residential and drywall carpentry, 1999–2001

| Mechanism of injury | Rates[A] (95% CI) journeymen | Apprentices | Rate ratio[B] |
|---|---|---|---|
| Struck by or against | 5.6 (4.7, 6.6) | 10.4 (8.7, 12.5) | 1.9[C] |
| Overexertion | 2.6 (1.9, 3.4) | 2.7 (1.8, 3.9) | 1.0 |
| Falls from height | 1.5 (1.1, 2.1) | 2.8 (1.9, 4.0) | 1.9 |
| Same level falls | 0.72 (0.42, 1.2) | 0.69 (0.30, 1.4) | 1.0 |
| Repetitive activity | 0.43 (0.20, 0.79) | 0.26 (0.50, 0.76) | 0.61 |

[A]Rates are per 200,000 hours worked; based on interview data; estimate 20% higher if respondents are representative.
[B]Ratio apprentice/journeymen.
[C]Statistically different from 1 at 0.05 level of significance.

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 benefited 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.

**TABLE IX**
Factors reported by carpenters to be associated with injury by injury mechanism active injury surveillance union residential and drywall carpentry, 1999–2001

| Conditions/factors | Frequency (percent)[A] |
|---|---|
| Speed of work | 77 (16.6) |
| Time pressures | 71 (15.3) |
| Weather | 61 (13.2) |
| Slippery surfaces | 54 (11.7) |
| Task too heavy | 45 (9.7) |
| Coworker | 42 (9.1) |
| Needed help | 35 (7.6) |
| Housekeeping | 32 (6.9) |
| Fatigue | 25 (5.4) |
| Wrong tool for task | 15 (3.2) |
| Storage of materials | 14 (3.0) |
| Lighting | 8 (1.7) |
| Needed training | 8 (1.7) |

[A]Percent of those answering this item.
Note: Categories are not mutually exclusive.

## 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. 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 (16.9 per 200,000 hours worked) is considerably higher than recent Bureau of Labor Statistics (BLS) rates[2] 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[17] and by Glazner et al.[18] 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,[19] 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

**TABLE X**
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<br>• Un-hook tools from power supply before working on them<br>• Training in use of power tools for apprentices<br>• Cut metal materials bands with snips and bend them over to avoid cut hazard; throw away when able to remove them.<br>• Adequately brace framed walls |
| Overexertion | • Use assistive equipment: levers, lift devices, cranes<br>• Get proper help for heavy tasks<br>• Do not push so hard<br>• Work as a team for heavy tasks |
| Fall from same level | • Install cleats on walk boards<br>• Improve grading of site early in project<br>• Increase frequency of site housekeeping<br>• Backfill foundation early |
| Fall from height | • Check integrity of all work surfaces; scaffolds, ladders, sub-flooring, roof, joists, top plate of framed wall<br>• 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<br>• Use more fall protection: more toe boards, guardrails, tie off more<br>• Use cranes to avoid some risks; setting I-beams, large windows<br>• Cover and mark openings<br>• Replace pic boards and ladder jacks with pump jacks |
| Caught | • Secure adequate help to raise framed walls<br>• Use assistive devices, cranes to “set steel”<br>• Put something (like blocks) under anything heavy as you build to avoid having to get under it to lift |

of awareness of onsite 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 underreporting. 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.[20] 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.[16,19] 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.[21]

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[22] is more likely to occur in a meaningful manner. The ongoing collection and continued analyses of these data by specific mechanism of injury will provide more stable rates, as well as more information on the circumstances surrounding injuries, which should be even more revealing.

## 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 an unskilled task 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.

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.

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(A copy of the questionnaire used in the injury investigations will be sent by Hester J. Lipscomb [Box 3834, Duke University Medical Center, Durham, N.C. 27710] upon request.)

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