Falls in Residential Carpentry and Drywall Installation: Findings From Active Injury Surveillance With Union Carpenters

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Active injury surveillance was conducted with a large, unionized workforce of residential and drywall carpenters over a 3-year period. Injured carpenters were interviewed by trained carpenter investigators and sites were visited where falls occurred. Qualitative information was collected on exposures, risk perception, training, and mentoring. Falls accounted for 20% of injuries. Same-level falls were often related to weather, carrying objects—sometimes with an obstructed view—housekeeping, terrain of the lot, and speed of work. Falls from height occurred from a variety of work surfaces and involved ladders, scaffolding, roofs, work on other unsecured surfaces, unprotected openings, speed, and weather conditions. Recognized fall protection strategies, such as guardrails, toe boards, tying off to appropriate anchors, and guarding openings, would have prevented many of these falls; these practices were not the norm on many sites. (J Occup Environ Med. *2003;45:881–890*)

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Falls are the leading cause of occupational fatality in the construction industry, as well as a major source of morbidity.[1–4] As a group, carpenters are at high risk,[4,5] and there are data reporting particularly high risks among carpenters in residential construction and drywall installation.[5–7] These workers are difficult to study from an epidemiologic perspective. Their job sites change rapidly, and there are few workers on any given site, making assessment of their changing exposures challenging. Carpenters in these types of construction are less likely to be unionized and often have temporary employment, making them more difficult to enumerate.

Coded workers' compensation data provide information on the nature of injuries sustained and what falls occurred from or through (scaffold, ladder, opening) for both fatal falls and the vast majority of falls that do not result in death. However, codes are typically assigned from limited information provided on the first report of injury and many claims are coded only as a "fall to a lower level" or "fall from elevation," lacking useful detail.[6,7] These data also lack information on the circumstances surrounding injuries from falls that would allow formulation of specific preventive recommendations. They provide no information on the job site; availability, use, or failure of fall protection equipment; or activities of other workers that may have contributed to the injury.

We report on falls identified through active injury surveillance over a 3-year period among a large cohort of union residential and drywall carpenters. Through this effort, circumstances surrounding injuries sustained from falls were described, site conditions were assessed, injury rates were estimated, and preventive measures were identified.

Materials and Methods

Data Sources and Collection

Through partnership with the Carpenters' District Council of Greater St. Louis and the Homebuilders Association of Greater St. Louis, an active injury surveillance program was conducted for 37 months (September 1999 through September 2002) in the area surrounding St. Louis, Missouri; the only area of the United States with a large, unionized workforce of residential carpenters. Residential and drywall contractors agreed to report Occupational Safety and Health Administration (OSHA) recordable injuries (requiring medical care above first aid, loss of consciousness, or loss of work time or restricted duty beyond the day of injury) to the project office by facsimile or phone as they occurred. Union carpenters in this geographic area install drywall but do not do the taping or finishing. This report describes the investigation of reported falls among these carpenters.

The surveillance approach was modeled after the National Institute for Occupational Safety and Health (NIOSH) Fatality Assessment Control and Evaluation (FACE) program.[8] In contrast with 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 safety training specific to the construction industry (OSHA 500). They were trained in procedures to obtain informed consent and the administration of a standard questionnaire for investigation of these injuries. In addition, the investigators visited the job site where the fall had occurred. To supplement these data, a series of focus groups were conducted separately with apprentices and journeymen.

The questionnaire and site visit tool were developed with a steering committee, 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, time in the union, age, gender, safety training, weather conditions, and exposures or conditions caused by nearby workers. The carpenters were asked what, in their opinions, caused or contributed to their injury. Interviews were conducted by phone. The investigating carpenter reported his own assessment of contributing factors and preventive recommendations in addition to those offered by the injured carpenter. The tool was pretested in the field over 3 months, including 46 investigations, with review and discussion of findings by the carpenter interviewers and the research team.

The site visit tool was designed to assess the presence and control of fall hazards on job sites such as use of guards/rails around openings, slide arresters on roofs, fall protection equipment, a fall protection plan for the site, and conditions of ladders and scaffolds. Measures felt to reflect the overall safety climate on the site were also assessed. The condition of electrical cords, saw guards, scaffolding, and ladders were rated as acceptable or not based on predetermined criteria. General site conditions, such as housekeeping, materials storage, access/egress, and backfill around the foundation, were graded as excellent, good, fair, or poor by the carpenter investigator. Initial site visits were made by both investigators followed by discussion of their findings and rating criteria. Midway through the project, a series of eight site visits were conducted by both investigators at the same time with the investigators making independent assessments. Findings did not vary by more than one grade on general site conditions.

Focus groups were conducted separately with apprentices and journeymen to collect qualitative data on work exposures, safety training, supervision and mentoring experiences, and perception of risk. The focus groups were part of an overall surveillance effort[9] and were not limited to issues related to falls. Apprentices were recruited through the apprenticeship school and were allowed time in their training schedules to participate. Journeymen were recruited by the union through job site safety luncheons held in the summer, union local leaders, and contractors. They participated at night after working. Each carpenter used an alias name in the focus groups for confidentiality.

Union carpenters receive health and retirement benefits through trusteed health and welfare funds. Contractors hiring union labor pay into the trust based on the hours worked by the carpenters they hire. The local trust provided us with the hours worked per carpenter by contractor for each month, providing a measure of work hours at risk for rate calculations.

Analyses

Descriptive statistics were generated from the surveillance interviews and the site visit. Distributions of age, gender and union status (apprentice versus journeymen) of the dynamic cohort were calculated. All falls, from height and the same level, were identified from responses to questions in the interview. Injuries were described by the nature, body region and mechanism based on the report of the injured carpenter. The proportion of cases resulting in lost time, beyond the day of injury, was also calculated. The injuries were stratified by those resulting from falls from the same level, falls from less than 6 feet, and falls from six

TABLE 1
Characteristics of Carpenter Cohort

Gender	
Male	5110 (99.5%)
Female	15 (0.29%)
Unknown	12 (0.23%)
Age in years*	
Mean (range)	32.7
Median	31
Range	18–71
Hours worked by union status†	
Apprentice	3,160,230 (33.8%)
Journeymen	6,047,468 (64.7%)
Missing	138,905 (1.5%)

* Age at time of first observation
† Count changed over period of observation as some apprentices became journeymen; therefore distribution of hours reported.

TABLE 2
Falls in Residential Construction and Drywall Installation, Union Carpenters 1999 to 2002, by Union Status

Type of fall	Frequency (%)	Rate (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			
Less than 6 feet			
Journeyman	15 (60.0%)	0.50 (0.28, 0.83)	1
Apprentice	10 (40.0%)	0.63 (0.030, 1.2)	1.3
Total	25 (100.0%)	0.53 (0.34, 0.78)	–
Six feet or more			
Journeyman	34 (54.8%)	1.1 (0.77, 1.5)	1
Apprentice	28 (45.2%)	0.93 (0.61, 1.3)	1.2
Total	62 (100.0%)	1.3 (1.0, 1.7)	–

* Rates are per 200,000 hours worked.

feet or more. The current fall protection standard for construction is designed to generally protect workers at heights of 6 feet or greater.

The sum of hours worked by the cohort during the 37 months was calculated; hours worked were stratified by union status (journeyman versus apprentice). Crude and stratified injury rates were calculated per 200,000 hours worked (100 person-years of full-time work); numerators for rates 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.[10]

The conditions observed on sites were summarized and stratified as the injuries were described above. The text descriptions were used to describe the circumstances of injury and identify possible preventive measures for these same three categories of falls. A series of queries and cross-tabulations assisted in this process. Analyses were done through Microsoft ACCESS[11] queries and export of data to SAS (Cary, NC).[12]

The focus groups were audio-recorded and transcribed; the transcripts were imported into N5 text analysis software.[13] A node structure was defined to allow the systematic cataloging of key concepts based on the focus group interview guides.

Results

The cohort consisted of 5137 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 1.

During the 37 months of data collection, 783 injuries were reported. Interviews were completed with 586 injured carpenters (75%). Seventy-five individuals were never reached by phone, making the participation rate 83% among those who were reached. Falls accounted for 20% ($n = 117$) of all injuries investigated. Interviews were conducted from the day of injury to 189 days postinjury; mean 16 days, median 7. Fifty-six percent ($n = 65$) were conducted within a week and 79% ($n = 92$) were conducted within 2 weeks.

Investigated falls occurred at a rate of 2.5 per 200,000 carpenter hours worked. In Table 2, the frequencies and rates of falls are stratified by union status (journeyman versus 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. Among carpenters who fell from heights 62 (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 3 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 4, factors identified as contributing to same level falls are

TABLE 3
Injuries Sustained in Falls by Nature of Injury and Body Region, Union Carpenters 1999 to 2002

	Head/ face	Upper Extremity	Trunk	Lower Extremity	Multiple	Total
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)
Falls from height						
Less than 6 feet						
Contusion		3	4	2		9 (36.0)
Cut	1	1		1		3 (12.0)
Dislocation		1				1 (4.0)
Fracture			1			1 (4.0)
Sprain/strain		2	3	5		10 (40.0)
Chipped tooth	1					1 (1.1)
Total	2	7	8	8		25 (100.0)
Six feet or greater						
Concussion	2					2 (3.2)
Contusion	1	5	5	6		17 (27.4)
Cut	1	2		2		5 (8.1)
Dislocation		1				1 (1.6)
Fracture	1	6	5	8	2	22 (35.5)
Sprain/strain		3	3	6	1	13 (21.0)
Multiple injuries					2	2 (3.2)
Total	5	17	13	22	5	62 (100.0)

TABLE 4
Factors Contributing to Same-Level Falls (n = 30), Union Carpenters 1999 to 2002*

Contributing Factors*	Frequency (%)†
Slipped	21 (70%)
Loss of balance	19 (63%)
Weather; rain/mud/frost	11 (37%)
Carrying object/materials; weight of materials	9 (30%)
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 tasks)	1 (3%)

* Factors are not mutually exclusive.
† Represents percentage of falls with which this factor was associated.

presented. These are not mutually exclusive and, in fact, more than one factor was often related to a given fall. Two of these falls from the same level 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

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. The variety of surfaces from which these falls occurred are presented in Table 5 by distance of the fall.

Factors identified as contributing to falls are presented in Table 6. There were two cases in which fall protection failed; one toe board that broke under the man's weight and another in which a worker slid over the top of the toeboard. In only one case did personal protective equipment (fall arrest) contribute to the carpenter's injury. In this case, the carpenter 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, sustaining bruises on his arms and a cut on his face from the rope.

Site Visits

Ninety-five (95; 81%) worksite 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 7 separately for falls from the same level, falls of less than 6 feet, and falls of 6 feet or greater. 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 cir-

TABLE 5
Surfaces From Which Falls From Height Occurred, Union Carpenters, 1999 to 2002

Surface	Description of Surfaces	
	Fall From Less Than 6 feet	Fall From 6 Feet or Higher
Elevated work surface, total 33 (37.9%)	Top plate (1)	Top plate (6)
	Foundation wall/whaler board (3)	Foundation wall/whaler board (4)
		Floor joists (7)
	Rafters/trusses (1)	Rafters/trusses (4)
		Sub-floor (4)
		Ceiling joist (1)
	Deck around tub (1)	Homemade walk board (1)
	Total 6 (24.0%)	Total 27 (43.5%)
Scaffold, total 19 (21.8%)	Platform scaffold (Perry/Bakers) (2)	Platform scaffold (Perry/Bakers) (4)
	Horses/bench with pic boards (6)	Ladder jacks/pic boards (5)
	Scissors lift (1)	Patent scaffold (1)
	Total 9 (36.0%)	Total 10 (16.1%)
Ladder, total 14 (21.8%)		Extension ladder (6)
	Step ladder (4)	Step ladder (1)
		Multi-task convertible (1)
	Wall brace/using as ladder (1)	Job made ladder (1)
	Total 5 (20.0%)	Total 9 (14.5%)
Roof, Total 10 (11.5%)	Total 1 (4.0%)	Total 9 (14.5%)
Through opening, total 7 (8.1%)		Stairwell opening (4)
		Landing (1)
		Sub-floor (1)
		3rd floor window (1)
	–	Total 7 (11.3%)
Down stairs, total 2 (2.3%)	Total 2 (8.0%)	–
Other, total 2 (2.3%)	Pile of plywood (1)	
	Slide for material (1)	
	Total 2 (8.0%)	–
Total 87 (100.0%)	25 (100.0%)	62 (100.0%)

cuit protection and use of slide arresters on roofs. On sites where a fall from over 6 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

Six groups were conducted with a total of 54 apprentices. The majority were residential apprentices with at least 6 months of experience, although the groups included commercial and industrial apprentices. One group was conducted with 11 residential journeymen. The journeymen had been in that capacity for 3 to 20 years. Seven (64%) had completed an apprenticeship program; the others had grandfathered in based on their nonunion carpentry experience.

When asked generally about dangerous tasks, working at height was the most feared task described by apprentices, and walking the top plate was the most common exposure the apprentices talked about. Responses of 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 trade.

Fall protection taught in school did not necessarily follow to the worksite; more seasoned workers did not practice the techniques they were taught in the apprenticeship program. Journeymen were described as getting too comfortable with doing things "their way" and getting careless. Apprentices reported feeling powerless to make changes and they found themselves accepting the practices of the journeymen and more experienced apprentices.

"Once you get used to working in an environment that is unsafe, and you get used to working unsafe, then being unsafe is not unsafe to you anymore. It's just the norm."

"I mean what they [apprenticeship 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."

TABLE 6
Factors Contributing to Falls from Height, Union Carpenters, St. Louis Missouri, 1999 to 2002

Contributing factors*	Frequency (%)†	
	Fall from less than 6 feet (n = 25)	Fall from 6 feet or higher (n = 62)
Fall preceded by		
Slipping	7 (28%)	13 (21%)
Loss of balance	15 (60%)	33 (53%)
Working with tools	9 (36%)	28 (45%)
Handling materials	8 (32%)	26 (42%)
Time pressures/speed of work	6 (24%)	12 (19%)
Weather (mud, rain, snow, wind)	3 (12%)	9 (15%)
Housekeeping	3 (12%)	3 (5%)
Delivery, staging of materials	2 (8%)	5 (8%)
Inadequate help	–	3 (5%)
Co-workers' behavior/actions	2 (8%)	9 (15%)
Awkward work posture	–	1 (2%)
Collapse/failure of work surface	8 (32%)	24 (39%)
Needed ladder for task	2 (8%)	1 (2%)
Unprotected opening (heating vent, stairs, window)	1 (4%)	12 (19%)
Lack of safety training	3 (12%)	4 (7%)
Communication	1 (4%)	4 (7%)
Needed help	–	4 (7%)
Crane problems (setting I-beam, trusses)	–	2 (3%)
Fatigue	–	2 (3%)
Failure of fall protection	–	2 (3%)
Fall arrest system	–	1 (2%)
Ladder improperly set	2 (8%)	7 (11%)
Wrong ladder for task	3 (12%)	3 (5%)
Ladder failure/collapse	–	1 (2%)
Scaffold failure	2 (8%)	8 (13%)
Scaffold tipped/stepped off	3 (12%)	2 (3%)
Lack of rails on scaffold	1 (4%)	2 (3%)

* Not mutually exclusive.
† Represents percentage of falls from an elevation with which this factor was associated.

Journeymen reported that apprentices can increase their skill, and subsequent safety, by practicing work at height (walking a beam, for example, that is on the ground) but they also 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.

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 the group is behind 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 reported by both apprentices and journeymen. Apprentices, particularly, feared loss of their jobs if they could not work up to speed; the concern 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."

Although these themes were pervasive, there were exceptions. These carpenters reported, overall, that most things that should be done are done—somewhere by somebody—but they are not accepted industry wide. Where things were done right and attention was paid to safety, they were respected.

"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 everything, 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'."

The make-up of residential job crews was reported to vary somewhat but most consisted of a small team of men (usually three to five) 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. When additional manpower is needed for very heavy tasks, crews from another site are recruited to help. Clutter seemed to be pervasive.

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 report lacking this knowledge early in their careers—at times when they are expected to use this equipment.

Residential work was described as extremely demanding both physically and psychologically. At 6 months of experience, working at

TABLE 7
Site Conditions Observed by Type of Fall, Union Carpenters 1999 to 2002

	Height of Fall (% Observed; Number of Total Observations)		
Conditions Observed	**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	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)
Handrails in place	69% (13)	77% (16)	67% (33)
Fall Protection*			
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)

* Safety nets, ladder cages never observed.

heights was still viewed as a challenge to many. Standing, walking, or stooping on a 3.5-inch wide top plate or "riding the ridge" when setting trusses were mentioned most often as the most dangerous aspects of their jobs. 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. 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 phenomenal. 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've 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."

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."

Discussion

Falls accounted for 20% of injuries reported and investigated among these carpenters; falls from heights were twice as common as from the same level. Although falls from 6 feet or greater appeared to result in more serious injuries, over 70% of all falls, from height or the same level, resulted in lost time beyond the day of injury. Falls from the same level and those from height occurred at similar rates among apprentice and journeymen carpenters. Over 60% of the carpenters who fell reported having had fall protection training. There was only one injury associated with the use of personal protective equipment; this fall was arrested at 12 feet and resulted in minor injury.

Factors associated with falls involved a mix of human, object (equipment, tools, materials), environmental, and organizational factors. 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 surfaces. Those from less than six feet most often occurred from horses/benches being used as an elevated work surface, step ladders, and foundation walls. At times workers who fell less than 6 feet were working at heights higher than that. Falls from 6 feet or greater most often occurred when work was being done on a roof, floor joists, top plate of a framed wall, extension ladder or from a pic board set on ladder jacks. The fall was often the result of an unsecured work surface, unprotected openings, as well as, use of tools or handling materials, speed and weather conditions. In several situations, alternative methods were available, but not used, to avoid the carpenter working from the top plate from which he fell.

Some conditions contributing to these falls were related to site management, or work norms. These included work around and over open stairwells or windows, failure to brace ladders, and housekeeping, for example. Although some clearly reflect failure to adhere to safety standards designed to prevent falls, all are not. In addition, 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[14] reported 63% of nonfatal 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[15] among carpenters bear striking similarity to circumstances identified in these investigations, documenting that the margin between injury and fatality can be small.

The focus group data provided significant insight into challenges for fall prevention, and safety in general, on small residential construction sites. Some work at height is clearly perceived as being dangerous and worthy of respect, even if not adequate protection. Other high risk areas, such as unprotected openings for example, were not perceived as particularly risky needing only "common sense" to avoid. The speed of the work, and even fear of loss of work if you slowed the process down, were viewed as impediments to safety. Apprentices did not always have adequate fall protection training before coming on job sites, and even when they did, they often saw journeymen failing to use best practices. There were examples of good safety programs and practices, but these varied by contractor and were not seen as the industry standard.

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,[16] but is not essential in understanding the circumstances surrounding the falls.

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. No information could be collected on injuries that may have been prevented by fall protection activities including use of fall arrest equipment. 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 because of 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 more detail on circumstances surrounding falls among carpenters than available through other sources such as insurance records or the BLS summaries. As recommended by other injury scientists,[17] 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. 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[8] 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[18] allowed the identification of multiple intervention points for any given injury. In this case, these were from the perspective of injured workers and experienced journeymen investigators.

Regulations exist that are designed to protect construction workers from danger of work, specifically, on scaffolds and ladders, as well as when generally working at heights.[19] OSHA also has specific plain language guidelines for fall protection in residential construction.[20] These analyses were not focused on identifying compliance with regulatory measures per se, rather toward the identification of circumstances associated with falls. In fact, in a number of situations there was clearly not lack of compliance, but the worker still fell and sustained an injury.

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. 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. 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. 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. It is easy for carpenters to create traps for themselves and coworkers as the structure is being raised. 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.

Prejob and pretask fall protection planning and ongoing supervision by foremen and superintendents are crucial to assure necessary equipment and protective gear are available and that standard procedures are followed to prevent falls throughout the project. 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 practice.

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 of which were felt to contribute to these falls. While it is impossible to modify the weather, there are 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. Although work needs to be performed 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 effectively in order to work as a team. These are skills that are not typically taught as carpenters learn their trade, but are essential to working safely.

Apprentices receive some fall protection training as part of their school training often in the form of video demonstrations, 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 indication from these data that, in fact they do not, being more likely to adapt the practices of more experienced carpenters with whom they work.

Workplace norms that incorporate constant vigilance and preventive behaviors likely will only change through a combination of training and policy. 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.

For the particular workforce we studied, the union has a role in providing training and establishing norms for how work at heights by their members is to be done. In a union environment, it is expected that apprentices will receive training in school, but also learn from more experienced journey over the years of their apprenticeship. Residential construction typically involves few workers at any given site doing fast-paced work. Both conditions raise questions about how effective mentoring can best occur that allows inexperienced workers to learn skills and safety while working. These challenges are also applicable in non union environments where most residential construction is done in the U.S. While not addressed in this study involving English speaking workers, the effect of language barriers potentially becomes significant with the marked increase in Latino workers meeting demands for residential construction work in the U.S. Contractors bear responsibilities to provide appropriate equipment, training and safety policies that will protect all the workers they hire.

Existing standards designed to protect individuals working at height need to be followed and would have prevented a number of these injuries. However, there is the need to recognize that meeting such measures will not prevent all falls and should be viewed as minimal efforts. A serious fall can set a project back, cost large amounts to the contractor in direct and indirect costs, and result in huge personal costs to carpenter and his family that all should be prevented.

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