Assessing Fall Risks in Residential Construction

B. Evanoff[a], V. Kaskutas[a], A. Dale[a], H. Lipscomb[b]

[a]*Division of General Medical Sciences, Washington University School of Medicine, Campus Box 8005, St. Louis, MO 63110, USA*

[b]*Division of Occupational and Environmental Medicine, Duke University Medical Center, Box 3834, Durham, N.C. 27710, USA*

Abstract

Falls are a leading cause of mortality and morbidity in the construction industry, yet most falls could be prevented through the use of current recommended fall prevention strategies. As part of an ongoing needs assessment designed to improve training and use of fall prevention strategies on residential worksites, 447 apprentice carpenters at various stages of training were surveyed and 105 residential worksites audited. Preliminary analysis of data suggests apprentices perform work at heights prior to adequate training, and report work behaviors at odds with their demonstrated knowledge of fall prevention. Worksite observations find that fall prevention behaviors are practiced inconsistently. Further data analyses will better define barriers to appropriate fall prevention behaviors among residential carpenters. These data will guide a comprehensive curriculum intervention aimed at reducing falls in the carpenters' apprenticeship program.

Keywords: fall prevention, training, apprenticeship, carpenters, construction, injury prevention

1. Background and significance

1.1 Injury risk among construction workers

Occupational injury rates in the construction trades are high compared to the general workforce in the U.S. Recent BLS data, the primary source of data on occupational injuries and illnesses in the construction trades, reported injury rates in the construction trades of 8.3 per 200,000 hours worked [1]. Construction workers not only have higher rates of work-related injuries than other trades but they are among the most likely workers to experience serious occupational injuries [2]. Risk of injury does not appear to be equal for all groups of construction workers. Inexperienced workers have been described as being at greater risk of having a serious work related injury [2] as have workers at smaller-size construction employers [3]. Deaths due to injuries are often observed among younger individuals with shorter periods of union membership [4].

1.2 Fatal Falls

Falls, along with electrocutions and injuries involving motor vehicles and machinery, are leading causes of occupational fatalities in construction, accounting for 69% of construction deaths in the U.S. 1988-91 [5]. Proportionate mortality data indicate that union construction carpenters and union laborers have excess deaths due to traumatic events including falls [4,6]; among male construction workers younger than 65 excess deaths were seen due to falls [6]. Death certificate analyses conducted

on all fatal occupational falls 1980-89 in the U.S. construction industry, using the National Traumatic Occupational Fatalities surveillance system at NIOSH Division of Safety Research, identified 2798 deaths due to occupational falls in construction. These falls represented nearly half (49.6%) of all fatal occupational falls across all industries.

1.3 Nonfatal falls

Nonfatal occupational falls are also a serious problem in the construction trades. Hospital emergency department surveillance data on urban construction workers revealed that 64% of cases serious enough to require hospitalization were the result of falls [7]. A study in West Virginia found that 63% of nonfatal construction falls claimants had training in fall protection, but fall protection was not commonly used [8].

Falls are not just a public health problem of commercial construction workers but also a significant problem among individuals involved in residential construction. Data from Washington State workers' compensation claims between 1990 and 1995 demonstrated that residential single-family housing had the highest overall absolute number of claims for injuries and illnesses and the 4th highest rate of injuries [9]. Falls from elevations occurred at a rate of 1.13 per 200,000 hours worked among N.C. residential construction workers -- the third most common type of injury behind injuries resulting from being struck and overexertion injuries [10]. More recent data restricted to union carpenters in Washington State revealed that individuals whose union local primarily did residential carpentry were at particularly high risk for falls from elevation compared to their union counterparts in other areas of construction (rate ratio 3.0; 95% CI 1.8, 5.0) [11].

A recent NIOSH funded active surveillance project, the St. Louis Injury Prevention Project or *SLIPP*, provided detailed information on falls among a large cohort (n=5,137) of residential carpenters over a three-year period [12,13]. The project, modeled after the NIOSH Fatality Assessment Control and Evaluation (FACE) effort, involved experienced journeymen investigators interviewing their peers who were injured from falls. The investigators also visited the worksites where falls occurred to assess fall hazards and the overall safety climate. Falls accounted for 20% of injuries of these residential carpenters. Falls from height occurred from a variety of work surfaces and involved ladders, scaffolding, roofs, work on unsecured surfaces, unprotected openings, speed of work, and weather conditions, in addition to other risk factors. Fall protection strategies, such as guardrails, toe boards, tying off to appropriate anchors, and guarding openings, would have prevented many of these falls, but these practices were not the norm on many sites [13]. Some of these findings are quite consistent with reports of others including the work of Cattledge et. al. (1996) described above. Fatal falls from FACE investigations among carpenters [14] bear striking similarity to the circumstances identified in these investigations, documenting that the margin between injury and death can be small.

1.4 Safety Interventions

Interventions aimed at reducing workplace injuries have taken many forms including personnel selection, technological interventions, training, poster campaigns, stress management, near miss accident reporting, comprehensive ergonomics, positive reinforcements including feedback and incentives, regulatory measures and enforcement of these measures through onsite inspections and citations, to name a few [15]. There is still much to be learned about the effects of these different types of interventions. A recent systematic review focused on the effectiveness of prevention of falls in construction revealed only three studies for review and very little data to support the effectiveness of current programs [16]. Two studies on educational efforts, outside the U.S., suggested that educational programs may decrease falls but methodological limitations restricted conclusions that could be drawn [17,18].

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1.5 Apprenticeship training for union carpenters

Apprenticeships are an important part of the construction industry, providing the work skills necessary to function in a semi-monitored system. Construction trainees typically receive formal classroom instruction for 3-4 years concurrent with on-the-job training under a mentorship by experienced journeymen carpenters. Both of these aspects of the training are necessary to provide basic knowledge and craft skills, experience for decisions with routine and non-routine on-the-job tasks and recognition of safety hazards at the work place.

Contractors expect that the joint labor-management apprenticeship programs train apprentices consistently on the necessary skills, practices and safety procedures. Co-workers trust that new apprentices have the required knowledge and skills to function safely and efficiently in the autonomous work setting. Apprentices must not only receive adequate training and knowledge in these skills, but must attain the confidence to perform and respond to various situations appropriately. Even though apprenticeship programs are at the core of construction skills and knowledge training, there are no known studies examining the training provided to apprentices and it's applicability to the work site. Therefore, it is not known whether apprenticeship-training programs adequately train apprentices for the hazardous work of residential construction.

The practical problems that make the study of construction workers and their health hazards difficult are particularly salient to residential construction work. These include frequently changing employers and work sites, temporary employment, and sporadic work patterns. Residential job sites are typically small with few workers at any given site. There are no permanent job sites, as in an industrial setting, in which to place environmental controls or to easily regulate or reinforce safety practices. These factors make it difficult to regulate, to inspect, and to study residential carpentry.

2. Research design

The overall goal of our study is to evaluate the effectiveness of fall protection training methods among apprentice carpenters. The project will follow the conceptual framework described by NIOSH for evaluation of strategies to prevent work injuries [19] moving through organizational and development phases prior to intervention, collection of outcome measures, analyses, and reporting. The primary site for our project is the St. Louis Carpenters' Joint Apprenticeship Program for Greater St. Louis and Vicinity. This four-year training program has 2,400 actively enrolled apprentice carpenters in the St. Louis program. The Carpenters District Council (CDC) of Greater St. Louis and Vicinity represents 90% of the residential carpenters' workforce in the area, and is the largest unionized residential workforce in the country.

In this paper we describe instrument development and initial data from a comprehensive needs assessment of the current fall protection training for apprentice carpenters. These data will drive the content of curricular changes and serve as a baseline measure against which to measure future changes.

All work has been conducted with a joint team of university researchers and carpenter instructors from the apprenticeship program. This project is still in its early stages, and the results we present below represent preliminary data and analyses.

We developed three instruments for baseline measurement: a Fall Prevention Questionnaire, a Residential Fall Hazard Audit, and a Brief Worker Interview. We reviewed existing surveys, audits, standards, and guidelines with subject matter experts in construction and carpentry. Instructors in the apprenticeship training program, journeyman carpenters, and apprentice carpenters participated in the design of the questionnaire and the worksite audit. The instruments also incorporated themes learned from focus groups of apprentice carpenters (n=36) at various stages of their training that were led by two of the investigators. The Fall Prevention Questionnaire consists of 70 items in the following domains: demographic data, employment data, fall history, fall prevention training at the apprenticeship school and on-the-job, perception of fall risk for work tasks, knowledge of OSHA standards or guidelines, work crew fall prevention behaviors, attitudes and confidence about fall prevention, barriers to fall protection, and effectiveness of training methods.

The 52-item Residential Fall Hazard Audit is a worksite audit meant to be performed by a journeyman carpenter that has undergone training in the administration of the instrument. Domains of the audit include general safety climate and housekeeping, floor joist and sub-floor installation, walking surfaces and edges, wall openings, truss setting, roof sheathing, ladders, scaffolds, and personal fall arrests. The audit also includes the type and stage of construction, type of dwelling, cycle type, cycle time, number in crew, and the appropriateness of work for weather conditions. The auditor also records an overall assessment.

At the time of the audit, each carpenter on the worksite is asked to participate in a Brief Worker Interview. After receiving consent, the auditor asks each carpenter on the worksite 11 questions, including age, time in carpentry trade, time in

carpentry union, status (journeyman or apprentice), stage of apprenticeship training, amount of safety training on the job, amount of fall protection training on the job, and availability of fall arrest equipment at present worksite.

A detailed Audit Protocol Rating booklet describes the audit process and detailed procedures for rating each audit item. 16 worksites were piloted with a team of both auditors and one researcher to establish consensus and examine inter-rater reliability.

3. Results

3.1 Focus group results

In focus groups, apprentices described the risks from the many of the tasks and environments they experience, and reported varying levels of attention to prevention activities on work sites. Apprentices reported performing work at heights prior to adequate training, and described work behaviors at odds with their demonstrated knowledge of fall prevention. They described issues that are important in understanding fall prevention behavior, including behavior of co-workers, trust in the work team, and contractor policies.

3.2 Worksite Audit Results

The 105 worksite audits performed to date have identified areas where fall protection practices can be improved. The phase of construction dictates which building processes are observed during the audit, so the percentages below are in most cases based on fewer than 105 worksites.

Preliminary data analysis reveals that controlled access zones (CAZ) were in place only 21% of the time the auditor determined they were required, and all necessary aspects of a CAZ according to OSHA residential guidelines were in place only 5% of the time. At every site where first truss installation was observed (4 sites), workers were positioned in an unsafe position. Installation of common trusses and removal of the webbing from the truss met the audit criteria 17% of the time. Extension ladders were not secured at the top and bottom 72% of the time and the extension ladder did not extend beyond the landing surface half of the time. Floor joists were installed with workers standing in unsafe positions 69% of the time and workers lifted boards while on rafters or roof in unsupported positions 67% of the time. Debris was noted in walkways and/or access areas 63% of the time. Slide guards were usually in place, constructed correctly, and at correct intervals, although several roofs lacked any form of fall protection while roof-sheathing operations were occurring. Carpenters worked on stepladders that were unopened and leaning on a wall 47% of the time. Guardrails were not in place at leading edges or openings 40% of the time, and 44% of the stairs lacked a handrail. At the 5 sites where fall arrest was in use, the lanyard was inappropriate at 2 of these sites as it was too long to arrest a fall. Carpenters were observed walking on the exterior top plate during building operations at 9 of the 45 sites where workers were working at or near the top plate; walking the top plate appears to be a significant problem though this stage of construction is short.

The few times that ladder jack and pump jack scaffolds were observed (7 and 3 times respectively) they were usually constructed and used appropriately; however 2 of the 7 job built scaffolds did not have a secure and stable platform. No unsafe ladders were found in operation, though ladder use was frequently unsafe.

The worksite auditor completed 292 Brief Worksite Interviews. 85% of the journeyman and apprentice carpenters interviewed stated that the contractor's fall protection plan had been communicated to them. The amount of reported on-site safety training by contractors ranged from 0 (16 respondents) to 350 times per year; fall prevention training ranged from 0 times per year (24 respondents) to 300 times per year.

3.3 Fall Prevention Questionnaire Results

To date, 447 apprentices at various stages of the apprenticeship-training program have completed the survey during class time, with a 99% response rate. On the questionnaire, most of the apprentices note that their work crew consists of 4 carpenters, of which 2 are apprentices. The majority of the apprentices work for contractors that employee over 100 carpenters. Most respondents frame single-family homes. 53% of apprentices surveyed note that they have a friend, coworker or acquaintance that has experienced a serious fall from a height at work, yet only 76 (17% of respondents) had personally fallen from a height at work in the past year. These falls occurred most frequently from stepladder,

truss/rafter, top plate or extension ladder. Over 90% of those sustaining falls did not receive medical care, go on light duty, or lose work time. The average distance fallen is 9' (approx 3 meters), with the range from 2-30' (60 cm to 9 m).

Many apprentices reported that they had received no training prior to performing specific work tasks, including extension ladder use (40%), step ladder use (44%), and ladder jack use (24%).

When asked to rate the amount of risk posed by various work tasks, the tasks perceived to be at highest risk included unprotected opening or edge, sheathing a roof, working on top plate, and working on a roof with greater than 9 in 12 pitch. The majority of apprentices surveyed perceived no fall risk with using a stepladder and working near unprotected window opening.

On the knowledge portion of the questionnaire, most apprentices correctly identified OSHA standards for fall protection height requirements in general (80%) and while on scaffolds (70%), and knew that extension ladders must be secured at both the top and the bottom (67%) and must extend 3' beyond the exit surface (58%). Most knew that standing on the external top plate is never permitted (55%), although 27% believed that standing on the external top plate is allowed to install trusses/joists and lay out rafters. The majority of apprentices (66%) did not know the correct definition of a hole (2" or 5 cm in diameter); most answered that a hole was 12" or 30cm in diameter.

The survey includes 5 questions about work crew behaviors; apprentices reported that they often observed crew members using a step ladder leaning on a wall (39%), standing on exterior top plate (40%), and walking on floor joists (36%). 83% of the respondents noted that step ladders are used leaning on a wall at least occasionally, and that standing on the exterior top plate is performed at least occasionally 72% of the time. 48% of the apprentices note that fall arrest is not used on their work sites, yet 13% note that fall arrest is used often or always. 21% of apprentices reported that floor openings are never monitored.

Most apprentices were confident that they could prevent a fall from heights, build a ladder jack correctly, and use a harness correctly. Most also agreed that journeymen teach them how to do the job safely, that safety is a priority with management and foremen, that there is adequate time to work safely and meet production deadlines, and that they feel free to report safety violations. 84% stated that they had never been asked to "sign off" on safety training that they did not attend.

5. Discussion

Our preliminary data and analyses suggest that carpenter apprentices perform work at heights prior to adequate training, and report work behaviors that do not match their demonstrated knowledge of fall prevention. Risk perceptions are often at odds with the actual risk of the work task performed, and knowledge about a work task is not a good predictor of behavior for that work task. For example, the majority of apprentices know that walking the exterior top plate is never allowed, and most perceive that this task represented a severe risk of falling. However, the majority report that crewmembers regularly walk the exterior top plate, and standing on the exterior top plate was noted at several worksites audited. Commonly used equipment (ladders) are frequently used incorrectly, while less commonly used equipment such as scaffolding and ladder jacks were more often used properly. Worksite observations find that fall prevention behaviors are practiced inconsistently. Training for some tasks does not appear to match well with the exposures at the worksite. For example, apprentices rarely receive training in stepladder use, yet stepladders were observed at most worksites and unsafe behaviors on stepladders were frequently noted.

Further data analyses will better define barriers to appropriate fall prevention behaviors among residential carpenters. These data will guide a comprehensive curriculum intervention aimed at reducing falls in the carpenters' apprenticeship program.

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